U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-277 087

Environmental Overview of Texas Lignite Development

Radian Corp, Austin, Tex

Prepared for

Industrial Environmental Research Lab, Research Triangle Park, N C

Jan 78

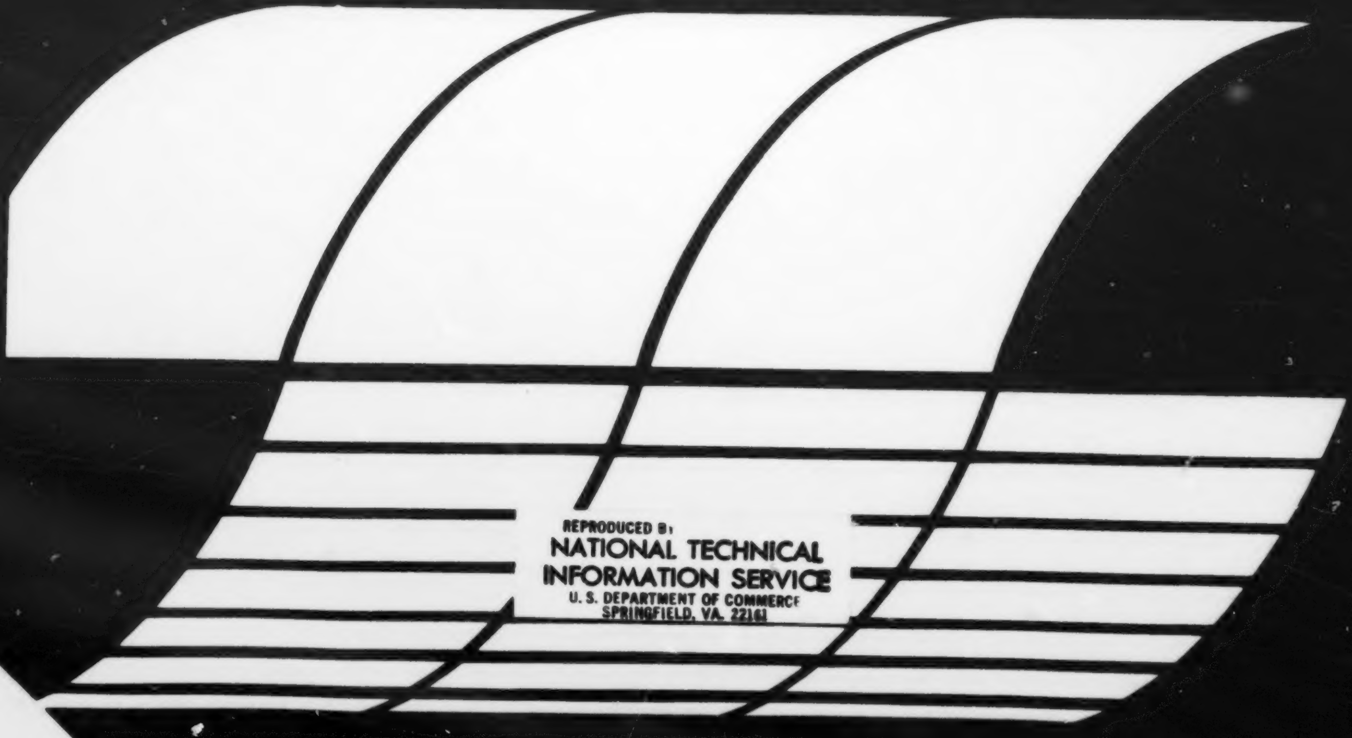
PB 277 087

PA

EPA-600/7-78-003
January 1978

ENVIRONMENTAL OVERVIEW OF TEXAS LIGNITE DEVELOPMENT

Interagency
Energy-Environment
Research and Development
Program Report



REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into seven series. These seven broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The seven series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development

This report has been assigned to the INTERAGENCY ENERGY-ENVIRONMENT RESEARCH AND DEVELOPMENT series. Reports in this series result from the effort funded under the 17-agency Federal Energy/Environment Research and Development Program. These studies relate to EPA's mission to protect the public health and welfare from adverse effects of pollutants associated with energy systems. The goal of the Program is to assure the rapid development of domestic energy supplies in an environmentally--compatible manner by providing the necessary environmental data and control technology. Investigations include analyses of the transport of energy-related pollutants and their health and ecological effects; assessments of, and development of, control technologies for energy systems; and integrated assessments of a wide range of energy-related environmental issues.

REVIEW NOTICE

This report has been reviewed by the participating Federal Agencies, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/7-78-003

2.

3. REC PB277087

4. TITLE AND SUBTITLE
Environmental Overview of Texas Lignite .
Development

5. REPORT DATE January 1978

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S) D. Harner, K. Holland, S. James, J. Lacy, and J. Norton

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Radian Corporation
8500 Shoal Creek Boulevard
Austin, Texas 78766

10. PROGRAM ELEMENT NO. EHE624A

11. CONTRACT/GRANT NO. 68-02-2608, W.A. 6

12. SPONSORING AGENCY NAME AND ADDRESS
EPA, Office of Research and Development
Industrial Environmental Research Laboratory
Research Triangle Park, NC 27711

13. TYPE OF REPORT AND PERIOD COVERED Task Final; 3-11/77

14. SPONSORING AGENCY CODE EPA/600/13

15. SUPPLEMENTARY NOTES IERL-RTP task officer is Roger P. Hansen, Mail Drop 63, 919/ 541-2815.

16. ABSTRACT
The report gives results of an investigation of possible effects of the development of Texas lignite, forecast to the year 2000 and based on a 10- to 20-fold increase of lignite utilization over 1976 levels. Lignite, a low-grade coal, is projected to provide an energy resource estimated to exceed proven oil and gas reserves of the State of Texas. Development of this resource will induce some major ecological, social, and economic effects throughout the entire Gulf Coast region. Secondary attention is given to effects in the other Gulf Coast states. Particular attention is paid to possible sociocultural impacts of development to largely rural communities, air and water quality problems, land use and reclamation practices, and plant siting procedures to lessen adverse effects of mine-mouth energy conversion facilities (lignite is unsuitable for long distance transport). Recommendations are offered for improved state/Federal standard setting, improved forecasting and data collection, and for a regional technology assessment of lignite development in the Gulf Coast states of Arkansas, Louisiana, Alabama, Mississippi, and Texas.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Land Use	Pollution Control	13B
Lignite	Reclamation	Stationary Sources	21D,08G
Energy	Plant Location	Texas	05A
Ecology		Gulf Coast States	06F
Sociology			05K
Economic Analysis			05C

18. DISTRIBUTION STATEMENT
Release to Public

19. SECURITY CLASS *(This Report)* Unclassified

20. SECURITY CLASS *(This page)* Unclassified

21. NO. OF PAGES 227

22. PRICE A11 - A01

EPA-600/7-78-003
January 1978

ENVIRONMENTAL OVERVIEW OF TEXAS LIGNITE DEVELOPMENT

by

D. Harner, K. Holland, S. James,
J. Lacy, and J. Norton

Radian Corporation
8500 Shoal Creek Boulevard
Austin, Texas 78766

Contract No. 68-02-2608, W. A. 6
Program Element No. EHE624A

EPA Task Officer: Roger P. Hansen

Industrial Environmental Research Laboratory
Office of Energy, Minerals, and Industry
Research Triangle Park, N.C. 27711

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Washington, D.C. 20460

TABLE OF CONTENTS

			Page
	EXECUTIVE SUMMARY		vi
1.0	INTRODUCTION		1
2.0	THE GULF COAST LIGNITE RESOURCE		5
	2.1	Occurrence and Characteristics of Texas Lignites	6
	2.1.1	Lithologic Units Containing Lignite	6
	2.1.2	Lignite Characteristics	6
	2.2	Recovery and Potential Use	16
	2.2.1	Mining	16
	2.2.2	Options for Utilizing Texas Lignite	18
	2.3	Factors Influencing the Potential Scale of Lignite Development	25
	2.4	Lignite Development Forecast	27
3.0	ENVIRONMENTAL SETTING		39
	3.1	Human Components	39
	3.1.1	Population	39
	3.1.2	Economic Structure	44
	3.1.3	Land Use	47
	3.1.4	Infrastructure and Recreational Resources	48
	3.2	Physical Components	51
	3.2.1	Climate and Air Quality	51
	3.2.2	Water Supply, Availability, and Use	55
	3.2.3	Water Quality and Trends	67
	3.2.4	Soils and Overburden	71
	3.3	Biotic Components	73
	3.3.1	Introduction	73
	3.3.2	Terrestrial Habitat/Vegetation Associations	75
	3.3.3	Aquatic Ecology	78

TABLE OF CONTENTS (Continued)

			Page
	3.4	Sensitive or Unique Areas	80
4.0	POTENTIAL ENVIRONMENTAL IMPACTS		85
	4.1	Socioeconomic Consequences of Lignite Development	85
	4.1.1	Direct Employment	86
	4.1.2	Indirect Employment	88
	4.1.3	Labor for Development and Population Change	90
	4.1.4	Demands on Infrastructure	91
	4.1.4.1	Housing	91
	4.1.4.2	Education	92
	4.1.4.3	Community Services	93
	4.1.4.4	Conclusion	94
	4.2	Cumulative Effects of Water Demands	94
	4.2.1	Demand Related to Lignite Development	94
	4.2.1.1	Direct Demands	95
	4.2.1.2	Indirect Demands	98
	4.2.2	Water Availability for Lignite Development	99
	4.3	Cumulative Effects on Water Quality	104
	4.3.1	Water Pollutant Sources and Pathways	105
	4.3.1.1	Mining Impacts	105
	4.3.1.2	Impacts of Power Generation	108
	4.3.2	Alterations to Hydrocarbons	111
	4.3.3	Secondary Effects on Water Quality	112
	4.3.4	Estimation of Aggregated Effects	113
	4.4	Cumulative Effects of Air Emissions	113
	4.4.1	Regulatory Framework	114
	4.4.1.1	Emission Standards	114
	4.4.1.2	Prevention of Significant Deterioration	115
	4.4.2	Dispersion Potential in the Lignite Belt	120
	4.4.3	Emission Control Technology	121

TABLE OF CONTENTS (Continued)

Page

4.4.4 Impacts on Air Quality by Emissions from Existing Sources........................ 125
4.4.5 Cumulative Impacts of Future Lignite Development.............................. 127
4.4.5.1 Basis of Impact Determination............. 127
4.4.5.2 Lignite Development to 1985............... 128
4.4.5.3 Lignite Development to 2000............... 134
4.5 Changes in Land Use...................... 138
4.5.1 Direct Effects........................... 138
4.5.2 Indirect Effects......................... 141
4.6 Cumulative Biological Impacts............ 142
4.6.1 Impacts on Terrestrial Communities....... 142
4.6.2 Impacts on Aquatic Communities........... 146

5.0 MAJOR ISSUES AND PROBLEMS SURROUNDING LIGNITE DEVELOPMENT....................................... 152
5.1 Issues Affecting the Scale, Location, and Timing of Lignite Development........... 153
5.1.1 Water Availability....................... 153
5.1.2 Consumptive Water Use................... 156
5.1.3 Water Use Conflicts..................... 159
5.1.4 Air Quality Maintenance................. 160
5.1.4.1 New Source Standards of Performance...... 160
5.1.4.2 Prevention of Significant Deterioration... 161
5.1.4.3 New Sources in Nonattainment Areas........ 165
5.1.4.4 Federal/State Conflicts.................. 167
5.1.5 Issues Related to Lignite Gasification.... 170
5.1.5.1 Factors Influencing the Development of Lignite Gasification..................... 171
5.1.5.2 Probable Future of Gasification in Texas.. 174
5.1.6 Issues Related to Mining................. 175
5.1.6.1 Assignment of Ownership.................. 175
5.1.6.2 Obtaining a Mining Permit Under PL 95-87.. 177

TABLE OF CONTENTS (Continued)

Page

5.1.6.3 Other Potential Issues Arising from PL 95-87 180

5.1.6.4 Effects on the Competition Between Lignite and Imported Coal 181

5.1.7 Capital Availability 183

5.2 Issues Surrounding Impact Mitigation 185

5.2.1 Water Quality 185

5.2.2 Growth Management 187

5.2.2.1 Planning for Increased Service Demand 187

5.2.2.2 Financing 189

5.2.2.3 Land Use Planning 191

5.3 Camp Swift: A Case Study of Federally Owned Texas Lignite 193

5.4 Summary Evaluation 197

6.0 RESEARCH NEEDS 202

6.1 Forecasting 202

6.2 Baseline Data and Impact Analysis 203

6.3 Developing National-Regional Problem-Solving Strategies 205

6.4 Developing State-Level Problem-Solving Strategies 207

BIBLIOGRAPHY 210

EXECUTIVE SUMMARY

The Resource

The Texas lignite resource is estimated at 122 billion tons of which 10.4 billion tons are amenable to surface mining (i.e., within 200 feet of the surface). The known portion of this "strippable" resource which can be mined under current technology, economics, and regulatory requirements is estimated at between 3 to 8 billion tons. Roughly three quarters of the near-surface lignite lies north of the Colorado River. The best quality lignite--higher Btu values, lower ash and sulfur contents--also predominate in the central and northeast portions of the Texas lignite belt.

The immediate prospects are that most Texas lignite will continue to be used as a boiler fuel for power plants near the lignite mines since long-range transport of lignite is not economically justified. Lignite is not suitable for slurrying; therefore, it appears that when lignite must be shipped--most likely for boiler fuel uses along the heavily industrialized upper Gulf Coast--the railroads will be the primary mode.

Currently, lignite-fired power plants account for 3,410 MWe of capacity (about 8 percent of the state total) with an additional 8,079 MWe officially announced for 1985. Lignite production has increased from 2.2 million tons per year (mtpy) in 1970 to 14.2 mtpy in 1976 with estimates for increases to 58.7 mtpy in 1985.

The economics of importing western coal vis-a-vis mine mouth lignite plants have been altered by the recent enactment of the 1977 Clean Air Act Amendments. This legislation requires the use of best available control technology on all new coal-fired plants. This measure removes the primary advantage of importing low-sulfur coal and may give Texas lignite a distinct competitive edge in satisfying future Texas boiler fuel requirements.

Based on electric utility power production alone, lignite demand is projected to increase from 18 mtpy in 1977 to 59 mtpy in 1985, and to a minimum of 128 mtpy and a maximum of 257 mtpy in 2000. The size of the surface-mineable resource itself may not sustain this upper limit. Assuming a hypothetical plant size of 1500 MWe (two 750 MWe units), the number of lignite-fired plants will increase from 9 to 1985 to between 16 and 30 in year 2000.

Potential Adverse Environmental Effects

Under the growth assumptions noted above, lignite development is forecast to increase 10- to 20-fold over 1976 levels. The socioeconomic and environmental impacts along the Texas lignite belt will be significant.

This growth is forecast to result in between 10,000 and 20,000 new mining jobs and between 6,000 and 13,000 jobs in new power plants by 2000. Secondary employment in the lignite belt is expected to result in between 31,000 and 64,000 new jobs by 2000 for a total employment of between 47,000 and 97,000. This could cause considerable impacts on a region characterized by small rural communities and decades of little or nor growth. Other socioeconomic impacts can be expected in public schools, a wide range of municipal services (such as water and sewer facilities), and the more subtle political and social conflicts between the influx of "newcomers" and the resident "old-timers".

A critical factor influencing the full-scale development of lignite is the availability of surface water. Water demands for lignite development are direct (reclamation and dust control in mining, boiler makeup, ash handling, stack gas scrubbing, and cooling in power production) and indirect (to serve the increased population). By 2000, direct demands will range from 228,000 to 427,000 acre-feet per year, most of which will be located in East and East Central Texas. By comparison, the indirect water use by 2000 is less than one-tenth the direct demands and is largely non-consumptive (water is returned to surface or subsurface sources). Based on forecasts of availability, these demands will seriously strain surface water supplies on a local basis resulting in sharp competition with other users.

For the long term, the greatest threat to water quality is a deterioration of the ground-water supply. Aquifers may be locally unusable for drinking water supplies if their recharge zones contain many unlined ash and scrubber sludge ponds. Without appropriate mining and reclamation controls, surface water may be polluted from eroded spoil banks and overburden.

Another possible environmental constraint on the forecast lignite development levels by 2000 is air quality regulation. Mine-mouth, lignite-fired power plants emit appreciable levels of particulates, sulfur oxides, and nitrogen oxides. Despite improvements in control technology, the announced new plants will result in a three-fold increase over 1975 levels during the next few years but still remain within state and Federal limitations. Currently, the lignite belt meets Federal ambient air quality standards. To insure that cumulative impacts on air quality due to significant plume interaction do not occur, 1500 MWe stations should be separated by about 30 miles. Closer spacing (to less than 10 miles) is possible, however, and is allowed by current law under some conditions. The actual spacing of plants is dependent on a variety of local factors requiring case-by-case analysis. The maximum of 30 plants forecast by by year 2000 cannot all be separated by 30 miles if sited at the mine mouth. This constraint could prohibit development at some locations unless stack-gas clean-up is raised to a level exceeding the New Source Performance Standards.

The total amount of land to be disturbed by Texas lignite development through 2000 could reach 454,000 acres. With adequate reclamation, the effects will be minimized. Much of the agricultural land to be disturbed is considerably less productive than agricultural lands on either side of the lignite belt. Since much of the mining and reclamation will occur in stages, the overall effect on wildlife habitat will be minimized. In fact, with the exception of mature forests, it is possible to reclaim much of the lignite belt lands such that wildlife carrying capacity can be increased. On a local level, aquatic life may be adversely affected by the deterioration in water quality. The additional demands on water quantity from lignite operations may exacerbate threats to the survival of aquatic populations in drought conditions. Other possible adverse effects on aquatic life may result from reduced freshwater flow to coastal estuaries and localized thermal loading from power plant cooling operations.

Policy Issues and Problems

The State's water rights appropriation system, operating on a first-in-time, first-in-right basis, may not be adequate to accommodate water use disputes resulting from lignite development. The recent combination of the three State water agencies into the Department of Water Resources may facilitate the development of a coordinated planning approach necessary to maximize benefits to all users. Although Federal initiatives may compel change, allocation based on price alone could drive agricultural users out of the market.

Similarly, the problem of maintaining adequate flow in streams to supply coastal estuaries could be addressed through the systematic operation of reservoir levels--a technique which is presently constained by legal and regulatory barriers. The location of lignite with respect to existing lakes, the seasonal variation in water availability and, to a lesser degree, Federal permitting regulations, have necessitated the widespread use of cooling ponds over the more water-conserving "once-through" cooling methods.

The deep basin (below the strippable zone) lignite resource is believed to be recoverable only through *in situ* gasification. The environmental advantages of this technology include the reduction of air pollutants and the elimination of surface mining. However, there is considerable uncertainty regarding the contamination of ground water from *in situ* combustion.

The likelihood of the commercialization of any form of lignite gasification is dependent on both advances in technology and policy decisions affecting the pricing and allocation of natural gas.

The mandatory boiler fuel conversion policies of the Texas Railroad Commission and the more severe gas phase-out requirements contemplated by Congress may provide an incentive to replace natural gas with a synthetic low- or medium-Btu gas for future use in existing peak-load gas-fired boilers. Gasified lignite may also replace some natural gas as a feedstock, However, the greatest potential for Texas lignite in this century is for use as direct-fired boiler fuel.

The problem of accommodating some 30 lignite-fired 1500 MWe units on or near the lignite belt in the face of current air quality regulations suggests the need for greater voluntary power plant siting coordination among utilities.

Texas lacks a consistent legislative policy regarding disputes that arise between surface owners and mineral right owners over the assignment of lignite ownership. The point is that surface mining will temporarily--and maybe permanently--affect the surface owner's use of this land. Recent State Supreme Court decisions, such as Reed versus Wylie, have ruled that lignite is assigned to the surface estate where no specific mention of surface mining is made in the mineral interest lease or deed. Although the issue is not clearly resolved, this situation could impede lignite development depending on the extent of such conflicting property rights.

On the whole, it appears that the additional requirements imposed on current State regulations by new Federal strip mining law will have less effect on the mining of Texas lignite than on the surface coal production in other regions where the overburden consists of prime agricultural land, environmentally sensitive areas, or unreclaimable and severely steep slopes.

The communities along the lignite belt are not prepared to cope with the multitude of environmental and socioeconomic impacts they may face during the next quarter century. Municipal governments are typically reluctant to act in the face of uncertainty regarding proposed developments.

Although most of the Texas lignite resource will be developed by private firms on private property, a unique exception is the more than 100-million-ton reserve on Camp Swift--an unused army training camp 30 miles east of Austin. A recent Federal law permits coal leasing on military property for use by publicly-owned utilities. On balance there appear to be no major unresolvable environmental problems associated with the development of Camp Swift lignite.

Further study needs include improved forecasting, a better data base for impact assessment, and more quantitative evaluation of impacts, air quality modeling and economic modeling. Numerous issues bear further examination, in particular the influence of exercising the state option of redesignating parts of the lignite belt Class III or Class I. Other issues claiming more attention are growth management, water conservation, and the energy conservation opportunities associated with lignite development. An in-depth, regional technology assessment, including the states of Texas, Arkansas, Louisiana, Alabama, and Mississippi, is recommended.

1.0 INTRODUCTION

Continuing energy shortages throughout the nation and changing fuel mixes in the Gulf Coast region indicate that the substantial lignite deposits of the Gulf coastal plain will be more intensively exploited as an energy source in the future. These low-grade coals are already being mined and used in Texas on a limited scale. Up to now, the emergence of lignite-related technologies has apparently not been accompanied by significant adverse environmental effects. However, the rapid expansion of lignite mining and utilization may generate both site-specific and cumulative adverse impacts that are not currently apparent. In particular, a number of policy-related issues may need to be resolved before development on a large scale can proceed in an environmentally acceptable manner.

The EPA Office of Energy, Minerals, and Industry, acting through its Special Studies Staff at the Industrial Environmental Research Laboratory, Research Triangle Park, North Carolina, has commissioned this study of potential environmental effects of Texas lignite development. The purposes of this environmental reconnaissance are several.

- to present an overview of the Gulf Coast lignite resource and the types and general scale of impacts and conflicts associated with its probable use

- to provide perspective and general guidance as to what additional information and analysis are likely to be useful in minimizing detriments and maximizing benefits related to lignite development

- to furnish an environmental issue-oriented appraisal of what EPA and other federal policies are likely to affect or be affected by lignite development, with special reference to the desirability and utility of a regional-level technology assessment

This environmental reconnaissance has been prepared by Radian Corporation, Austin, Texas, and is based on in-house experience, non-proprietary resources, and other information that is readily available. Lack of regional data and other limitations focus most of the analysis on Texas lignite. A special effort has been made to include only pertinent illustrative or documentary material.

This report is organized in six chapters, of which this introduction is the first. Chapter Two is a description of the lignite resource: what it is, where it occurs, how it may be used, and what affects its current and future uses. Also included in Chapter Two is an estimate of potential lignite development rates that is used for impact analysis and discussion.

Chapter Three characterizes the physical, biological, and cultural components of the lignite region of Texas and the Gulf Coast. The geographic variations and current trends in these characteristics are emphasized where appropriate. The chapter is specifically not intended to be a detailed description of the existing environment.

Chapter Four addresses potential environmental impacts associated with lignite mining and use. The assessment of impacts recognizes the types of site-specific effects that may occur, but generally emphasizes aggregated or cumulative primary and secondary effects and apparent resource conflicts. The lignite development scenario described in Chapter Two places the scale of these impacts in a temporal perspective.

Chapter Five presents a more detailed discussion of current issues related to lignite development. The issues are discussed chiefly from the standpoint of how they may affect the type, magnitude, location, and timing of changes in one or more environmental aspects. No attempt has been made to limit this discussion to those issues that are within the current purview of EPA, so that a more comprehensive picture may be obtained. However, this discussion should not be considered a complete enumeration of all potential problems and issues; rather it only illustrates some of the major ones and how they may interact with one another.

Chapter Six summarizes major areas in which further study is needed. It emphasizes the most obvious and pressing of these needs, where real data gaps exist or complex policy interactions must be disentangled. Finally, it discusses the need for a unified in-depth regional analysis.

2.0 THE TEXAS LIGNITE RESOURCE

Despite its size, the lignite resource of the Gulf States has not been extensively explored. Figure 2.0-1 illustrates roughly the geographic extent of the lignite-bearing formations through Texas, Louisiana, Arkansas, Alabama, and Mississippi. Only in Texas, where the size of the strippable resource is judged to be about 10.4 billion short tons, is there a reliable estimate of Gulf Coast lignites. However, strippable resources in the remaining states probably total several billion tons. Deep-basin lignite resources that may be amenable to in situ gasification may be an order of magnitude larger.

Because of the general lack of exploration and development in the other states, and insufficient data on the resource itself, the following discussions will center around the Wilcox and Yegua-Jackson lignites of Texas. Though these formations also make up the bulk of the Arkansas and Louisiana resource, generalizations must be made with caution on the basis of the Texas data. Sulfur and sometimes ash contents appear to be significantly higher in Alabama and Mississippi lignite, than in Texas, Arkansas, and Louisiana lignite. Heating values are also expected to be slightly higher in Alabama and Mississippi lignite.

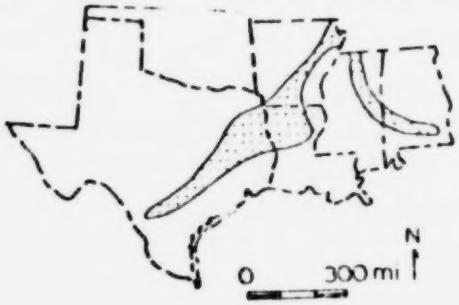


FIGURE 2.0-1
LIGNITE OCCURRENCE IN THE TERTIARY OF THE SOUTH-CENTRAL UNITED STATES

Preceding page blank

2.1 Occurrence and Characteristics of Texas Lignites

2.1.1 Lithologic Units Containing Lignite

Lignite is found throughout the Texas Gulf Coastal Plain from the Rio Grande to the Red and Sabine Rivers as near-surface and deep-basin deposits. Near-surface deposits occur within three principal outcrop areas of lower Tertiary (Eocene) rocks in East Texas (Figure 2.1-1). The principal commercial lignite deposits are found in the lower Eocene Wilcox Group, which crops out as a narrow band extending from Maverick County on the Rio Grande to Bowie County on the Red River. This unit also crops out in the Sabine Uplift region centered on Panola and adjacent counties. Deposits of secondary importance are found in the upper Eocene Yegua Formation and Jackson Group along a narrow outcrop band extending from Starr County on the Rio Grande to Sabine County on the Sabine River. Two areas of deep-basin lignite are located downdip and coastward from the near-surface deposits (Figure 2.1-2). The largest of these represents subsurface Wilcox lignite deposits (KA-152).

2.1.2 Lignite Characteristics

Lignite occurs as a component facies of ancient fluvial, deltaic, and lagoonal rocks. The northeastern deposits are associated with fluvial deposits. These grade into deltaic deposits in the central parts of the lignite belt and into lagoonal deposits in the southern regions. Detailed descriptions of these depositional frameworks are given by Kaiser (KA-152). Figure 2.1-3 shows the stratigraphic occurrences of lignite deposits.

Through an examination of known lignite deposits and their geological contexts, the Texas Bureau of Economic Geology (KA-152) estimated that a total of 10.4 billion short tons of

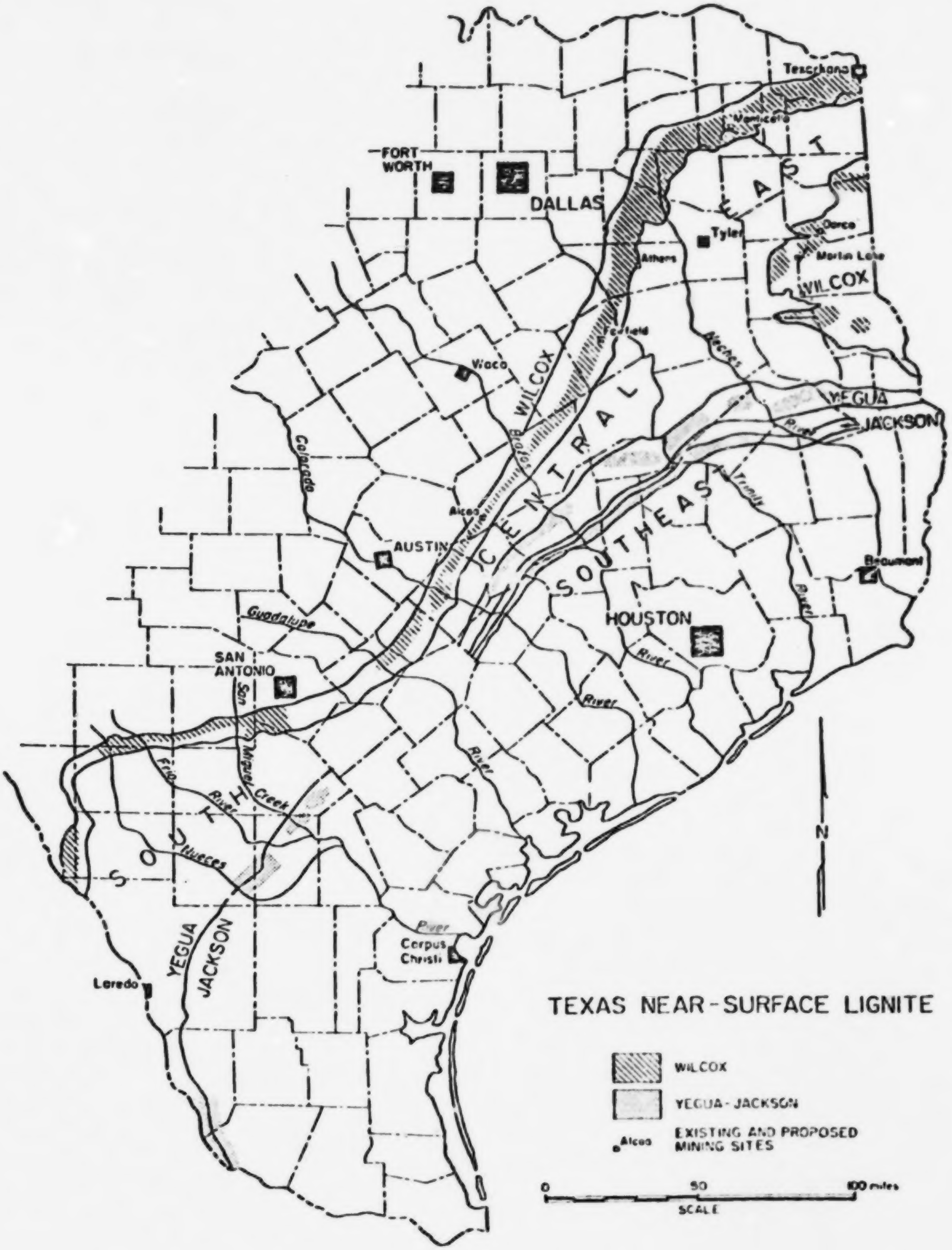

Texarkana
Monticello
FORT WORTH
DALLAS
EAST
Tyler
Darco
Martin Lake
Athens
WILCOX
Fairfield
Neches
Waco
WILCOX
CENTRAL
YEGUA
JACKSON
River
Brazos
Colorado
Trinity
Alcoa
AUSTIN
SOUTHEAST
Beaumont
River
Guadalupe
HOUSTON
River
SAN ANTONIO
San Miguel Creek
River
River
Frio
River
SOUTH
Nueces
N
River
Corpus Christi
Laredo
YEGUA
JACKSON
TEXAS NEAR-SURFACE LIGNITE
WILCOX
YEGUA-JACKSON
Alcoa
EXISTING AND PROPOSED MINING SITES
0
50
100 miles
SCALE

FIGURE 2.1-1

DISTRIBUTION OF TEXAS NEAR-SURFACE LIGNITE

(SOURCE: KA-152)

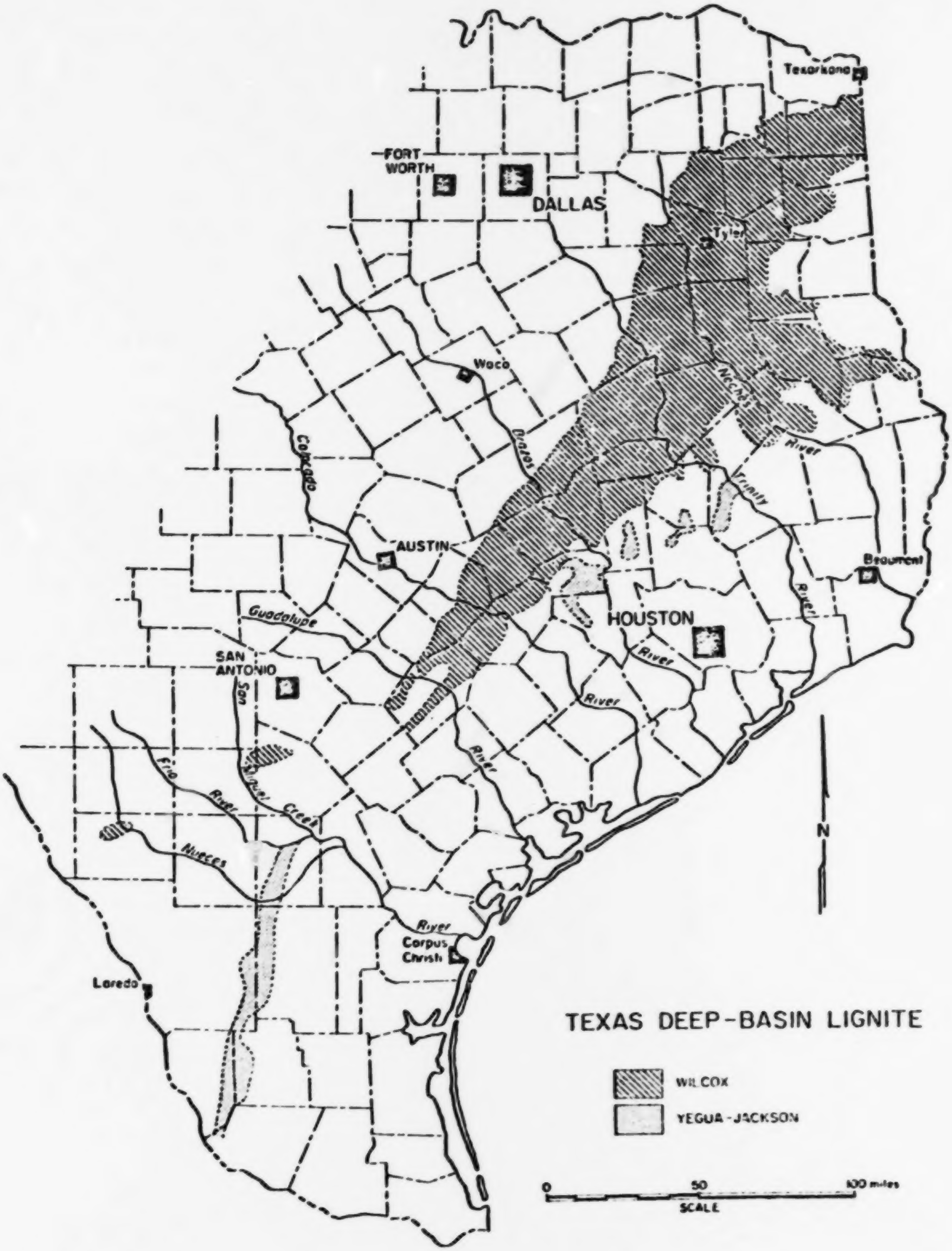

Texarkana
FORT WORTH
DALLAS
Tyler
Waco
Neches
River
Trinity
Brazos
Colorado
AUSTIN
Beaumont
River
HOUSTON
River
River
Guadalupe
SAN ANTONIO
San
River
Frio
River
Creek
Nueces
River
Corpus Christi
Laredo
N
TEXAS DEEP-BASIN LIGNITE
WILCOX
YEGUA-JACKSON
0
50
100 miles
SCALE

FIGURE 2.1-2

DISTRIBUTION OF TEXAS DEEP-BASIN LIGNITE

(SOURCE: KA-152)

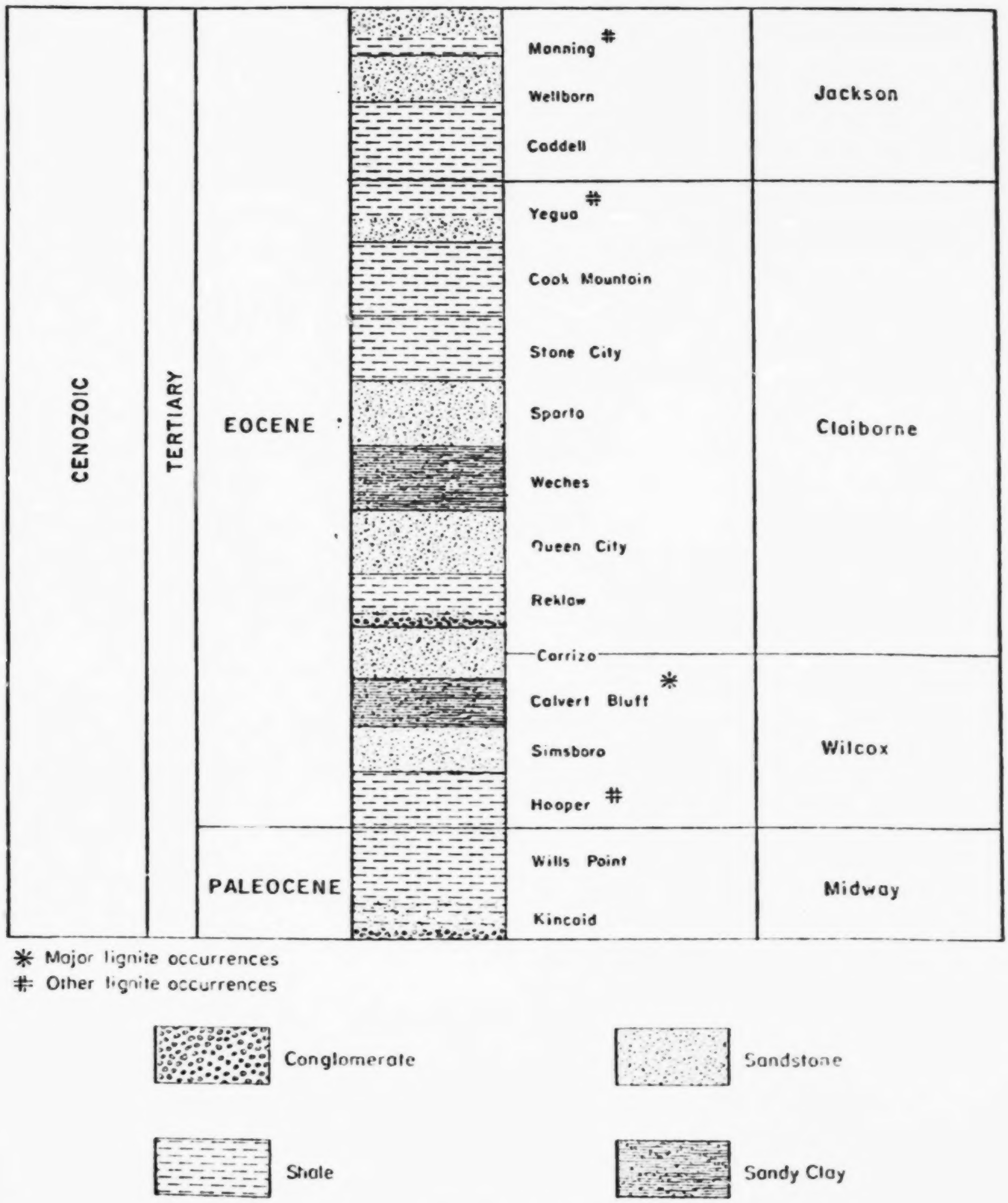

CENOZOIC
TERTIARY
EOCENE
PALEOCENE
Manning #
Wellborn
Caddell
Yegua #
Cook Mountain
Stone City
Sparta
Weches
Queen City
Reklaw
Carrizo
Calvert Bluff *
Simsboro
Hooper #
Wills Point
Kincaid
Jackson
Claiborne
Wilcox
Midway
* Major lignite occurrences
# Other lignite occurrences
Conglomerate
Sandstone
Shale
Sandy Clay

FIGURE 2.1-3

STRATIGRAPHIC COLUMN, EAST TEXAS; ADAPTED FROM THE GEOLOGICAL HIGHWAY MAP OF TEXAS lignite with a minimum thickness of 4 to 5 feet may be located within 200 feet of the surface (Table 2.1-1). These estimates have since been locally corroborated by actual exploration, and are thought to be a fairly accurate description of the amount of lignite which could have potential commercial value. Estimates of the known portion of this resource which could be mined economically with present technologies, economics, and regulatory requirements[1] have ranged from 3 to 8 billion tons (WH-124). Estimates of both the total resource and economically recoverable reserves are subject to revision as exploration proceeds. It should be noted, however, that the relatively low heating value of Texas lignite, and its high ash and sulfur content and thin seams, make the economics of production fairly marginal and highly sensitive to environmental policies affecting the cost of mining or use.

TABLE 2.1-1

NEAR-SURFACE POTENTIAL LIGNITE RESOURCES

	Amount (Billion Tons)	Percent of Total
East Texas	5.085	49
Central Texas	2.846	27
Southeast Texas	1.386	13
South Texas	1.109	11
Total	10.426	100

Source: KA-152

The extent of deep-basin lignites is less well known, but the Texas Bureau of Economic Geology estimates, using geophysical logs from oil and gas drilling, that at least 112 billion short tons are present. Most of this lies in the Wilcox Formation in Central Texas, from 200 to 5,000 feet below the surface.

---

[1] Prior to enactment of the Surface Mining Control and Reclamation Act of 1977.

Compositional variation in Texas lignite results in differences in grade or quality of these deposits. Figures 2.1-4 through 2.1-6 illustrate regional variations in heating values, sulfur and ash content. These characteristics were used to rank the desirability of the principal near-surface resources, shown together with other potential resources in Figure 2.1-7. This figure shows that the highest-quality lignite deposits are found in the Wilcox outcrop from Bastrop County to Bowie County and in Harrison, Rusk, and Panola counties in the Sabine uplift area.

The most economically attractive deposits (numbered 1 and 2 in Figure 2.1-7) have already been partly developed. To date, severe adverse environmental or socioeconomic consequences have not been observed in the vicinity of these mines, where post-development environmental studies have been made.[1] Subsequent development would normally proceed from these areas to the next most favorable ones, with the least favorable developing last. A number of other factors, however, may actually produce a somewhat different development pattern.

Presently the bulk of the best lignite is held by a few companies, most notably the Texas Utilities Company and several major oil and gas firms. Other would-be lignite users may therefore have to look to the less desirable but still available deposits. In addition, current clean air policies may restrict power plant siting options in the northeast and central areas of the lignite belt where the greatest demands and the best deposits of lignite lie. This situation will also favor the development of the less desirable deposits to the south earlier than would otherwise be expected, especially if the demand for lignite is high.

---

[1] The studies referred to are proprietary surveys conducted in the vicinity of the Sandow and Big Brown generating stations (see Figure 2.2-2).

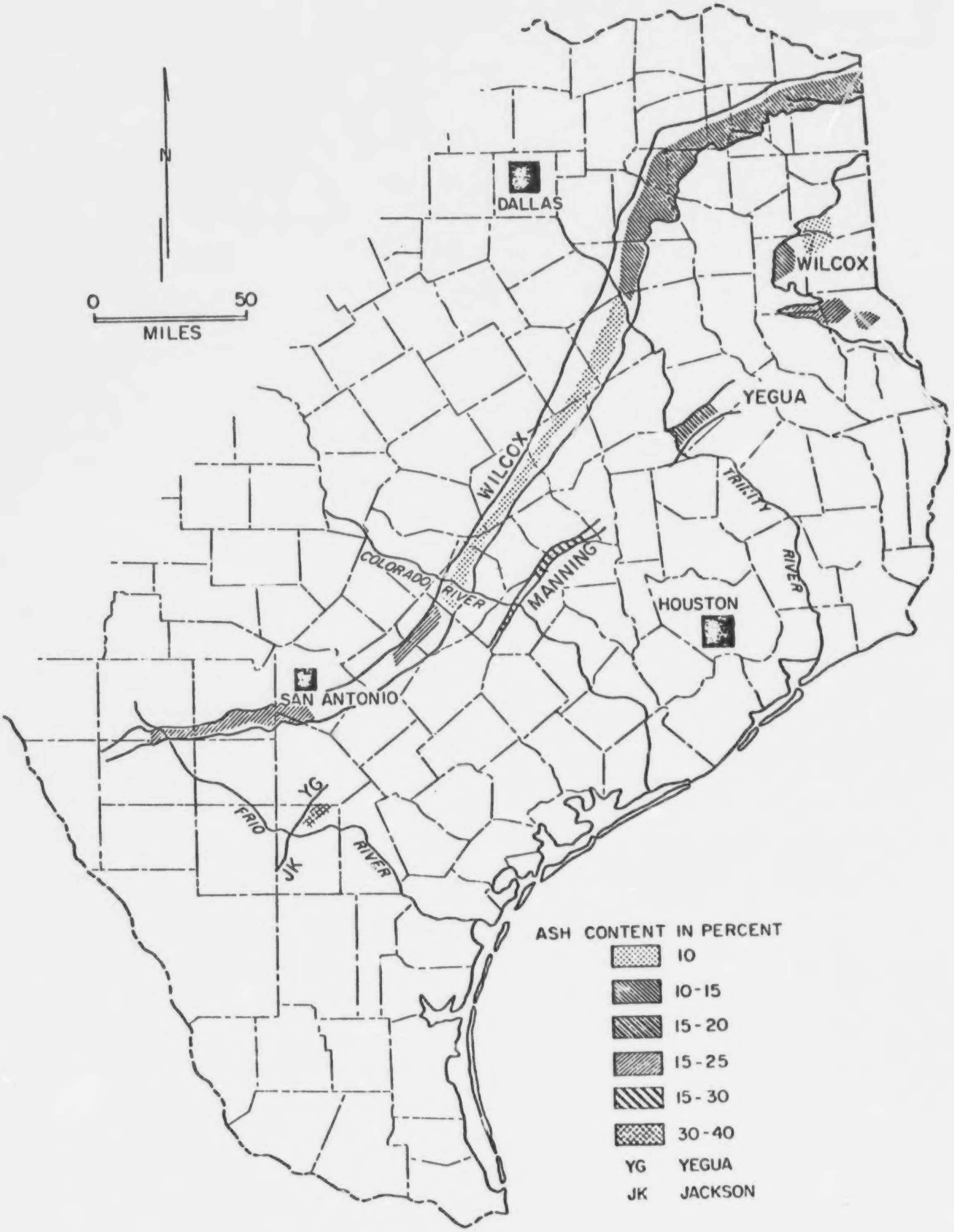

N
0
50
MILES
DALLAS
WILCOX
WILCOX
YEGUA
TRINITY RIVER
COLORADO RIVER
MANNING
HOUSTON
SAN ANTONIO
YG
FRIO RIVER
JK
ASH CONTENT IN PERCENT
10
10-15
15-20
15-25
15-30
30-40
YG YEGUA
JK JACKSON

FIGURE 2.1-4

REGIONAL VARIATION IN ASH CONTENT OF TEXAS LIGNITE

(As-Received Basis)

(SOURCE: KA-152)

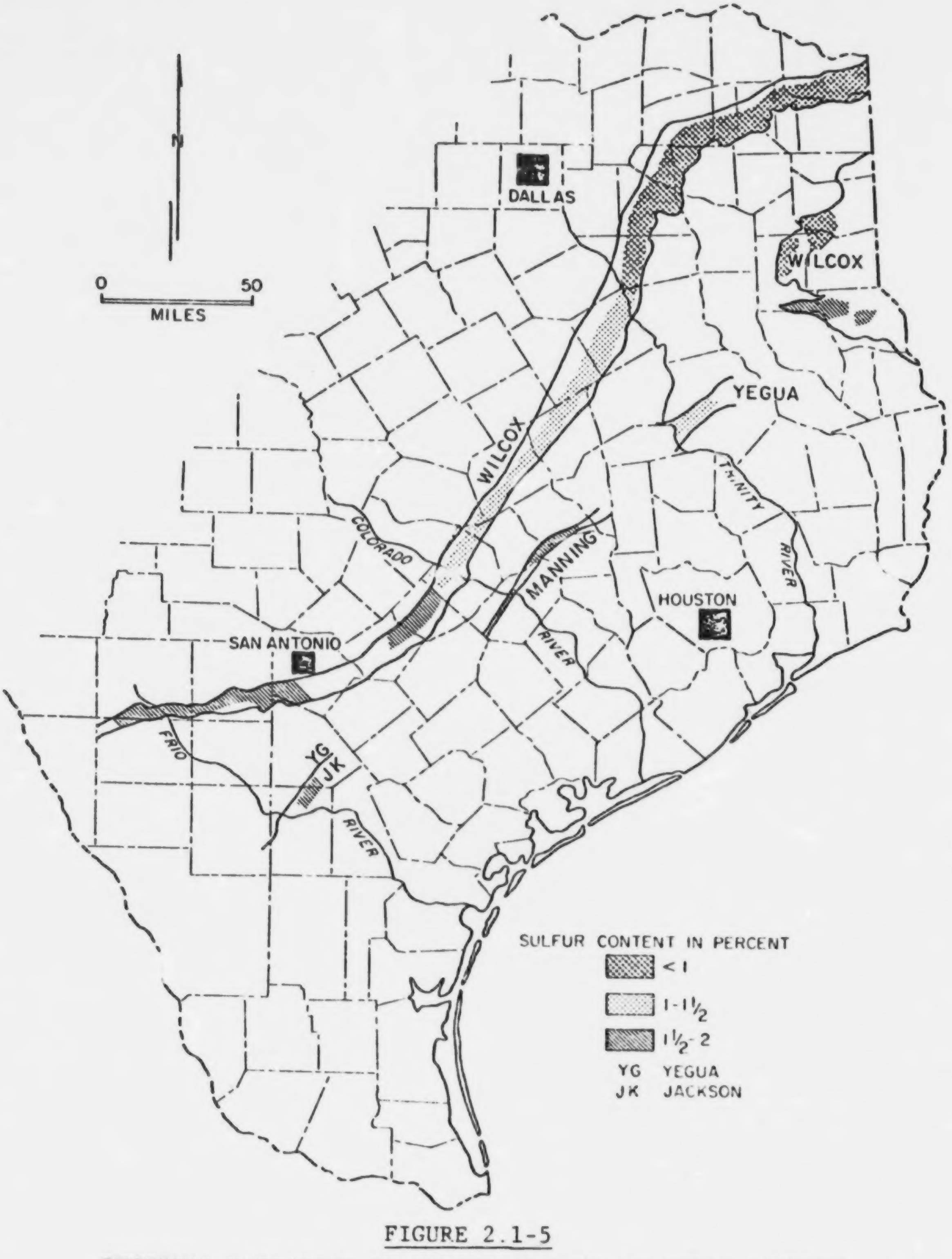

N
0
50
MILES
DALLAS
WILCOX
YEGUA
WILCOX
COLORADO
MANNING
TRINITY
RIVER
HOUSTON
RIVER
SAN ANTONIO
YG
JK
FRIO
RIVER
SULFUR CONTENT IN PERCENT
▨ < 1
▨ 1-1½
▨ 1½-2
YG YEGUA
JK JACKSON

FIGURE 2.1-5

REGIONAL VARIATION IN SULFUR CONTENT OF TEXAS LIGNITE

(As-Received Basis)

(SOURCE: KA-152)

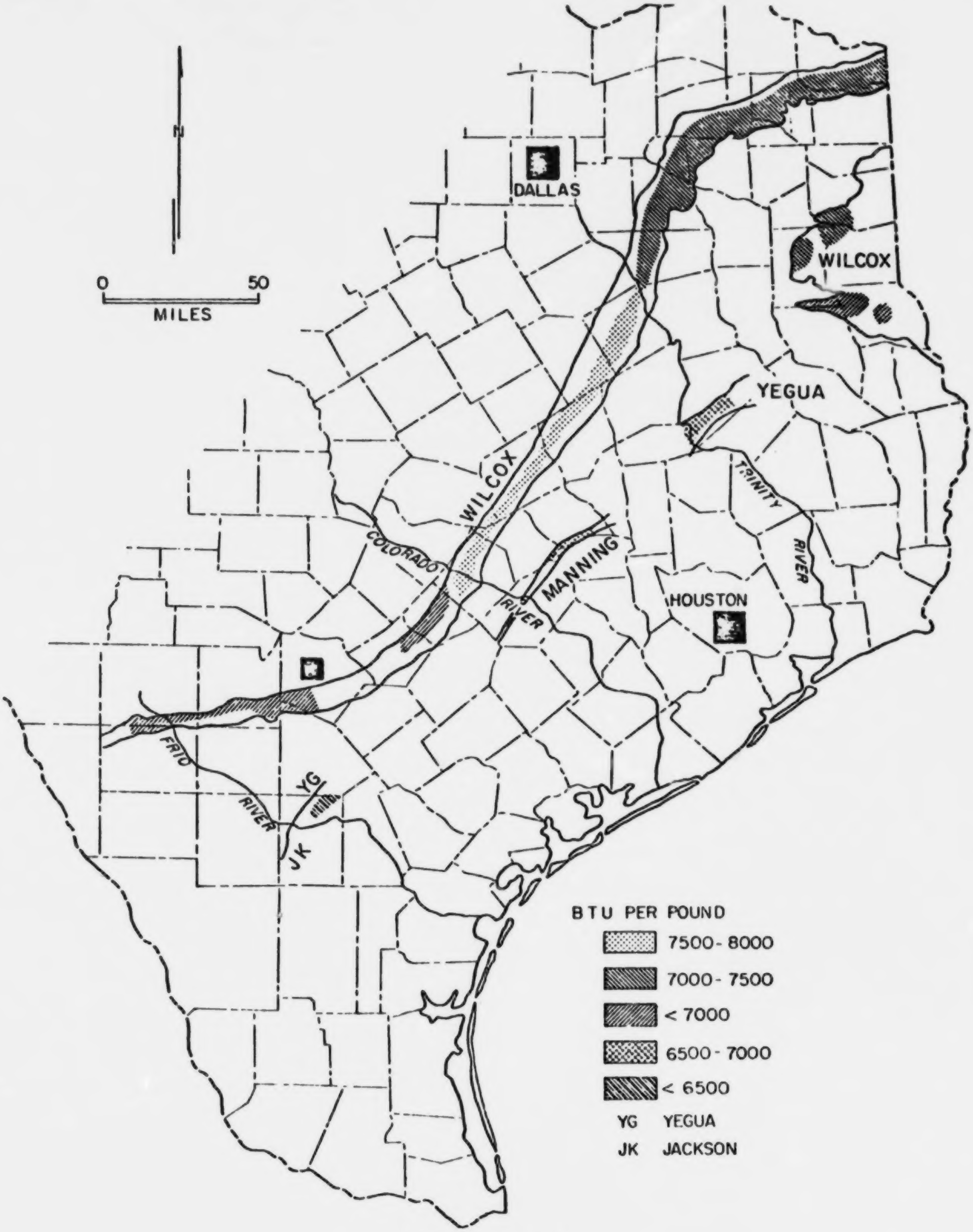

N
0
50
MILES
DALLAS
WILCOX
YEGUA
WILCOX
TRINITY
RIVER
COLORADO
RIVER
MANNING
HOUSTON
FRIO
RIVER
YG
JK
BTU PER POUND
7500-8000
7000-7500
< 7000
6500-7000
< 6500
YG YEGUA
JK JACKSON

FIGURE 2.1-6

REGIONAL VARIATION IN HEATING VALUE OF TEXAS LIGNITE

(As-Received Basis)

(SOURCE: KA-152)

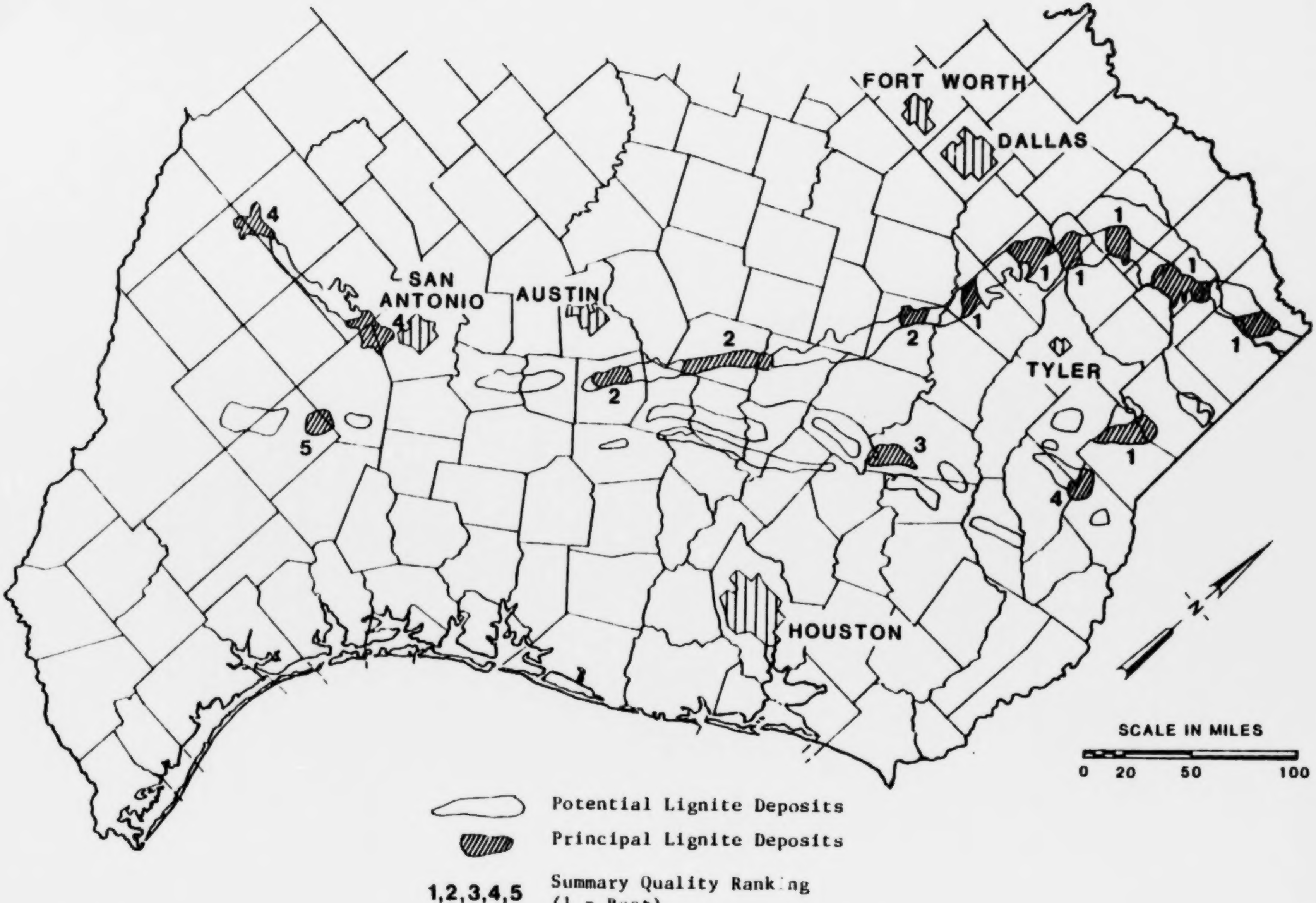

FORT WORTH
DALLAS
TYLER
SAN ANTONIO
AUSTIN
HOUSTON
1
1
1
1
1
1
1
1
2
2
2
3
4
4
4
5
N
SCALE IN MILES
0 20 50 100
Potential Lignite Deposits
Principal Lignite Deposits
1,2,3,4,5 Summary Quality Ranking
(1 = Best)

FIGURE 2.1-7

POTENTIAL AND PRINCIPAL LIGNITE DEPOSITS AND QUALITY OF EACH

02-1980-1

2.2 Recovery and Potential Use

2.2.1 Mining

Prior to 1946, most mining was by underground room-and pillar methods through shafts 30 to 150 feet deep. The Malakoff district in western Henderson County was the most important of the old mining districts. The Alba district of southwestern Wood County and the Como district of south-central Hopkins County were also very active from 1890 to 1946. Some open-pit mining also occurred, where holes 30 feet in diameter were dug.

Lignite is presently mined by area stripping. In flat to gently rolling terrain where lignite occupies a wide continuous area, overburden is removed in a series of rows. Overburden from the first row is piled next to the pit away from the direction mining will take, and the lignite is removed. Subsequent cuts are made parallel to the first and the overburden is deposited in the immediate preceding pit.

Modern earth-moving equipment and the availability of large lignite reserves below shallow, unconsolidated overburden make surface mining more economical than underground mining. Large shovels and draglines with 90-cubic-yard buckets remove overburden (KA-152). About 80 to 85 percent of the lignite bed is typically recovered.

The size of draglines presently available limits strip-mine depth to less than 200 feet. Because the Eocene deposits dip coastward at about two degrees, the strippable near-surface deposits are confined to a narrow band (ten miles wide at most), except in the Sabine uplift region, where some deposits are areally extensive.

Approximately 50 to 100 feet of overburden is typically removed. Lignite beds presently mined are from 6 to 15 feet thick with rare beds attaining 20 feet of thickness.

Present lignite-fired power plants (the dominant users of lignite) are built adjacent to surface mines. Lignite is either carried in 180-cubic-yard trucks over company roads or transported by conveyor belts to the plant. Because of the relatively low heating value of lignite (around 7,000 Btu/pound), it is not economical to transport long distances. A more important constraint, however, arises from the tendency of Texas lignite toward spontaneous combustion because of its high volatiles content. Because of this problem, lignite is generally used within 5 to 15 miles of the mine. Slurrying, which might otherwise permit shipment of lignite over long distances, presents problems when applied to lignite, which disintegrates easily and is difficult to separate from the slurry medium.

Reclamation as practiced at Big Brown begins by reworking the spoil with dozers and scrapers to contours and drainage patterns benchmarked in pre-mining surveys. Topsoil and underlying materials are very similar chemically and texturally; consequently topsoil is not segregated and respread. The reworked surface is then fertilized and disked. In the spring, coastal Bermuda grass is then planted by sprigging; in the fall, crimson clover is seeded in. The next year, the Bermuda can be harvested as hay. Small impoundments are developed for stock and wildlife use, with appropriate vegetation planted around them. In addition to restoring use to pastureland, studies are being conducted of the feasibiltiy of planting trees and row crops. Black locust, green ash, sycamore, cottonwood and several other native and introduced woody species have been planted. Shrubby species suitable for browse as well as trees are planted. Corn, soybeans, and sorghum have been grown successfully on the mine.

2.2.2 Options for Utilizing Texas Lignite

As is true of all United States coals, Texas lignite can potentially be combusted directly, or converted into synthetic gaseous and liquid products. A specially funded effort at Texas A&M is researching the possibilities of using World War II German technology to convert lignite to a variety of petrochemical products (see Chapter Five). However, the short- and mid-term possibilities appear limited to more conventional gasification and liquefaction technologies.

Convention combustion is by far the greatest potential use for Texas lignite in this century. Lignite has been used for steam-electric power generation in Texas since 1927, and currently supplies about 9% of the state's capacity. Today, 3,410 MWe are generated in lignite-fired stations. A total of 8,079 MWe of additional lignite-fired capacity is currently planned to be in operation by 1985. There are no technological impediments to direct combustion of Texas lignite, although the variability among the fuels may require combustion studies to optimize boiler operation.

The Texas lignite belt lies primarily within the utility service areas of four investor-owned electric utilities: Texas Power and Light, Southwestern Electric Power, Gulf States Utilities, and Central Power and Light, as shown in Figure 2.2-1. Between the service areas of Texas Power and Light (a subsidiary of Texas Utilities Services, Inc.) and Central Power and Light is a twenty-county area served by municipal and other public utilities. Texas Utilities Services, Inc. presently operates all of the installed lignite-fired steam electric stations in Texas for the private utilities (Figure 2.2-2). However, Imperial Chemical Industries (ICI-United States, Inc.) uses local lignite as a feedstock for manufacturing activated carbon near Darco, Texas.

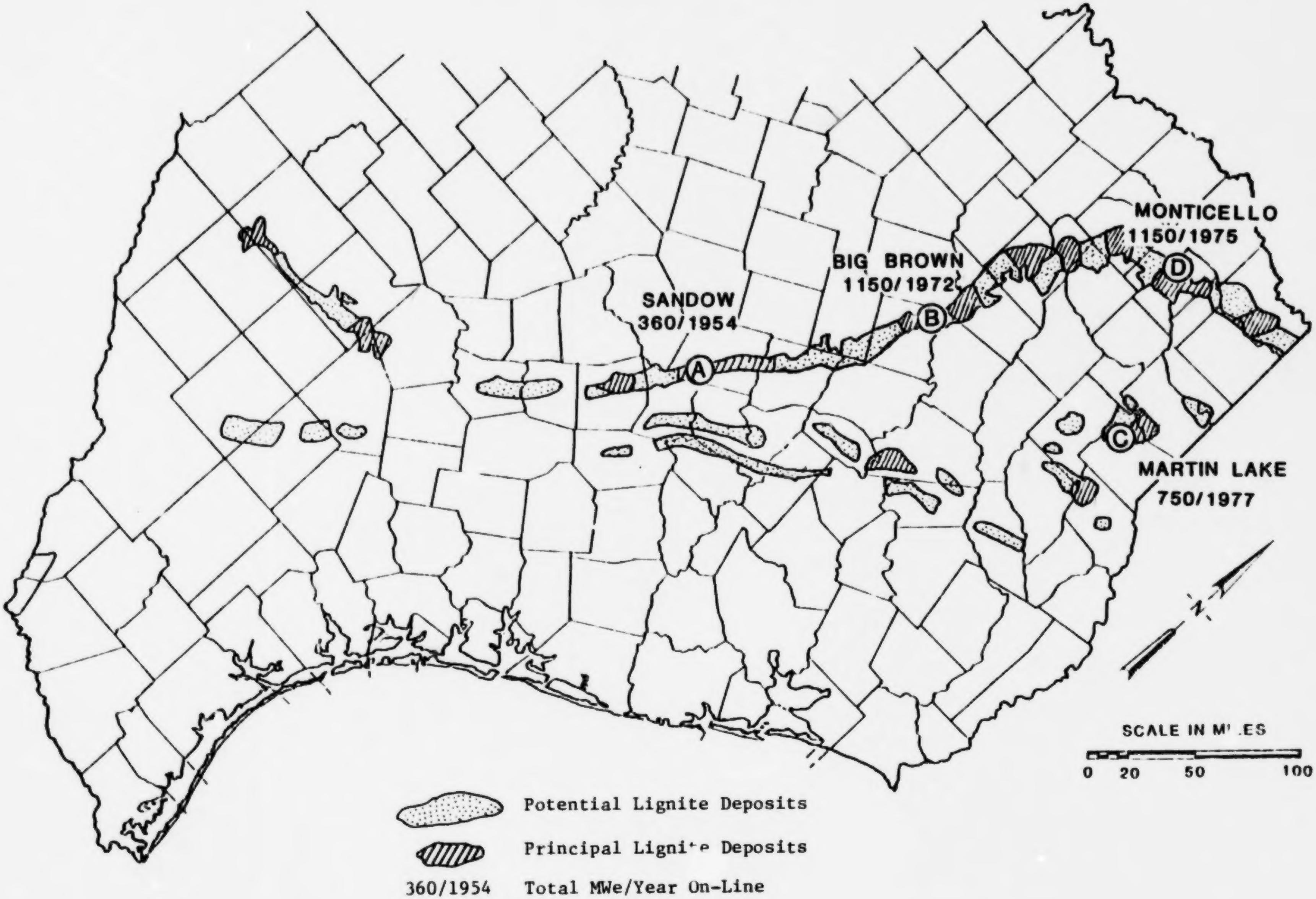

MONTICELLO
1150/1975
D
BIG BROWN
1150/1972
B
SANDOW
360/1954
A
C
MARTIN LAKE
750/1977
N
SCALE IN MILES
0 20 50 100
Potential Lignite Deposits
Principal Lignite Deposits
360/1954 Total MWe/Year On-Line

FIGURE 2.2-2

EXISTING LIGNITE-FIRED STEAM ELECTRIC STATIONS (1977)

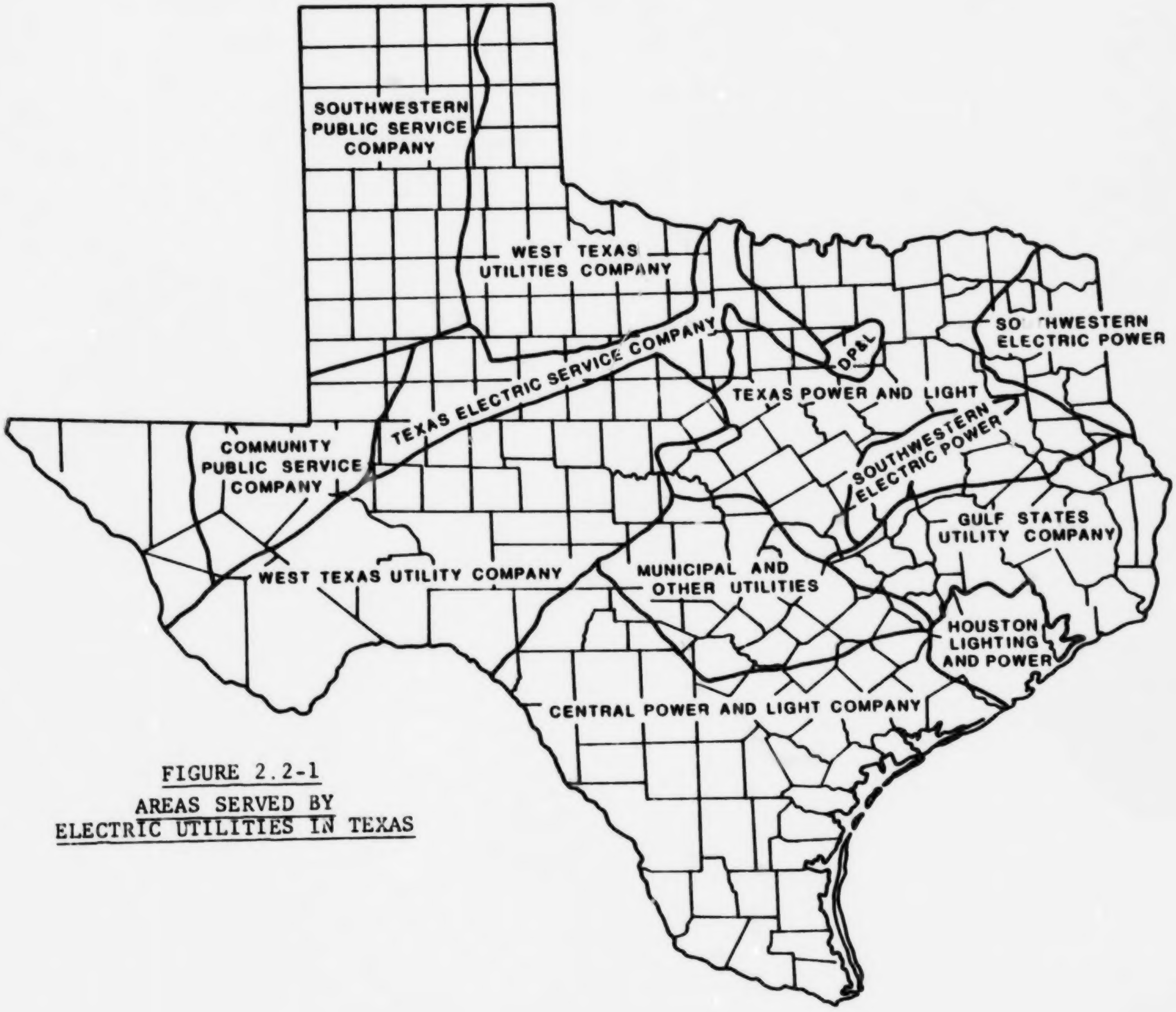

SOUTHWESTERN PUBLIC SERVICE COMPANY
WEST TEXAS UTILITIES COMPANY
TEXAS ELECTRIC SERVICE COMPANY
DP&L
SOUTHWESTERN ELECTRIC POWER
TEXAS POWER AND LIGHT
SOUTHWESTERN ELECTRIC POWER
COMMUNITY PUBLIC SERVICE COMPANY
GULF STATES UTILITY COMPANY
WEST TEXAS UTILITY COMPANY
MUNICIPAL AND OTHER UTILITIES
HOUSTON LIGHTING AND POWER
CENTRAL POWER AND LIGHT COMPANY

FIGURE 2.2-1

AREAS SERVED BY
ELECTRIC UTILITIES IN TEXAS

02-1978-1

As natural gas is phased out as a boiler fuel, most new generating capacity in Texas will be fired either with coal or with lignite. Until the passage of the Clean Air Act Amendments of 1977, the economics of using imported coal versus lignite in a large, new utility boiler were roughly equivalent. The cost of imported coal is high, especially when transported by rail. Per-ton delivered costs to Houston ranged from $20 to $23 in 1976 for Wyoming and Illinois coal, respectively. By 2000, these costs may rise to $40 or more, in 1976 dollars. The capital investment in rail cars, usually undertaken by the utility, as well as the cost of unloading facilities at the plant, adds to the cost. The total investment (in 1976 dollars) required to move 2 million tons per year of western coal a distance of 1,500 miles may be from $24 million to $28 million (WH-124).

Before passage of the Clean Air Act Amendments of 1977, it was possible to meet Federal New Source Performance Standards without scrubbers by using low-sulfur Western coal. Under these circumstances, the savings in flue gas desulfurization equipment and power consumption counterbalanced the higher cost of imported coal. Added to this, the additional capital and operating costs of the larger boilers needed to produce power from the relatively low-Btu lignite made the total economic outlook approximately the same for the two fuels. The new Amendments, however, call for flue gas clean-up or coal pretreatment, according to best available technology. Thus, this equalizing factor is now removed. Transport and coal costs now become dominant. Under these new requirements, lignite generally becomes the more attractive of the two. The recent imposition of steep severance taxes in Western states has further increased the attractiveness of lignite _vis-a-vis_ Western coal. Chapter Five contains a more detailed description of the potential impact of the Amendments on the scale of lignite development in Texas.

Much of the power generated with lignite will be consumed by industry. The 360 MWe Sandow station in Milam County presently supplies power to the adjacent Alcoa alumina reduction plant, while in Freestone County, the 1150 MWe Big Brown station produces electricity for the Lone Star Steel Company furnances. Both these plants are operated by Texas Utilities Generating Company. In addition, a substantial number of industries, particularly the petroleum refining and petrochemical industries, burn fuels on-site to produce heat, power, and process steam. In the future, increasing amounts of lignite will be used by these industries.

In addition to direct combustion, lignite can be converted to a liquid fuel or gasified for use as fuel or feedstock. Liquefaction processes, especially those based on pyrolysis, appear adaptable to Texas lignite, although there have been few tests to date of the suitability of such a liquid feedstock. Development of these processes lags behind gasification, and they have not yet been proven in a commercial operation in the United States. Furthermore, the wastewaters from these processes typically contain phenols and other toxic hydrocarbons, with trace metals and polynuclear aromatics up to saturation. Problems also exist in disposing of spent reagent solutions containing a variety of organic and inorganic compounds and trace elements. Biological treatment technologies, considered by many to be the most applicable approach to cleaning up these wastes, may take time to adapt, and will probably be difficult to operate. In addition, fugitive emissions associated with many liquefaction processes contain substances known or thought to be carcinogenic. The necessary tight housekeeping procedures to protect employee health will be costly, and could ultimately make liquefaction processes unattractive.

Gasification processes show more promise, both environmentally and economically. Gasification processes currently under investigation produce a low-Btu fuel gas, to be used directly as a boiler fuel (often immediately upon its exit, at a high temperature, from the gasifier). A medium-Btu "synthesis gas," high in hydrogen and carbon monoxide, may also be generated; its major use is as a feedstock, especially for ammonia and methanol production.

Texas lignite varies in quality as gasifier feed, and a batch test may often be the only way of determining its suitability. Typically, it is partially oxidized and high in volatile components, making it highly reactive. These characteristics, along with its non-caking properties, make it particularly well suited for certain processes, particularly the CO_2-acceptor process and the first-generation fixed-bed gasification processes. The fixed-bed processes preserve the volatile components of the lignite, including methane. Since ash from Texas lignite fuses at high temperatures, the new fixed-bed slagging Lurgi process now under development by the British Gas Corporation may prove even more applicable.

The first-generation gasification processes were largely developed for German brown coals, which resemble Texas lignite; there is, however, no direct operating experience with the Texas fuel. A pilot project to convert lignite to synthesis gas, funded by ERDA, is under way near Houston. Also, Exxon has proposed to build a Lurgi test facility near Longview, Texas, producing a medium-Btu synthesis gas to be piped to the coast.

Because the bulk of Texas' lignite resource is too deep for surface extraction and too low in heating value to justify the cost of conventional underground mining techniques, *in situ* gasification appears to be the only economical way of recovering its energy value. Present interest centers around technologies which first fracture the lignite, then introduce air and steam under pressure through one of a pair of boreholes. The resulting product gas is drawn off through a second borehole as the reaction proceeds. Econmically, this process is potentially very attractive because of its low capital and operating costs, relative to aboveground gasification. Furthermore, since the reaction proceeds underground, emission control is not a problem. However, the technology has not been proven commercially in Texas. Texas Utilities has leased rights to use a Soviet technology, reportedly proven in the U.S.S.R., which is being tested on the Wilcox lignite in Freestone County. Texas A&M University is also conducting studies of *in situ* gasification on the Yegua lignite near College Station.

Texas lignite appears very promising for *in situ* gasification. Its high reactivity and ash content may reduce or prevent problems of subsidence and water inflow by filling the voids left by the reaction. Since the process may produce relatively high concentrations of potentially harmful aromatics, some concern has been voiced over the problem of ground-water contamination. The deep-basin lignites, however, usually lie at some distance from freshwater aquifers. The strata immediately surrounding the lignite are also most often mud, which forms a relatively impermeable seal as the reaction proceeds. This not only retards water inflow, it permits high pressures to develop, which improves yields. The Texas Utilities pilot study carefully monitors water quality and will provide some concrete data on this question. Hydrologically, the lignites of the less permeable Yegua formation are generally less liable to ground-water contamination by leaching than those of the Wilcox. The reasonably thick seams of deep-basin lignites promote good utilization of the heat evolved, but slagging could tend to inhibit the gasification process (ED-073).

The leading factor affecting the development of a coal- or lignite-based gasification industry in Texas is the cost of producing and using synthetic gas, as compared to natural gas or direct combustion of coal. In general, trends in both capital and operating costs seem to favor the replacement of natural gas as a fuel with direct combustion of coal or lignite. Recent studies have investigated intermediate measures, in which older, natural-gas-fired equipment remains in service, fired with synthetic gas. These do not appear to be as cost-effective as building new coal- or lignite-burning facilities, even at the cost of phasing out extensive existing facilities. Peaking units appear to be the only exception.

The economics of converting smaller boilers include the additional factor of siting. In some instances, an industrial facility may be unable to convert to on-site direct combustion of coal because space is unavailable for the needed coal storage and handling facilities and for disposing of ash and scrubber sludge. The aggregate cost of converting a large proportion of such users to a synthetic fuel base is unfavorable for the same reasons that apply to large utilities: in addition to building gasification facilities, modification must be made in processes and equipment to use the new fuel. A few may simply be shut down and replaced, especially if owned by large concerns that can capitalize the development of new sites. However, there may be a potential for supplying a small proportion of them with synthetic gas, if a single gasifier can be built to serve several users. Co-generation or other cooperative ventures burning lignite directly to produce process steam and heat afford another possible avenue, competing with gasification.

2.3 Factors Influencing the Potential Scale of Lignite Development

Given the present trend of national energy policy and the decreasing supplies and rising costs of natural gas and oil, it is clear that Texas' use of solid fuels will increase dramatically by the end of the century. The state's economy is in large part founded upon the abundance of oil and natural gas. Now that cheap oil and gas supplies are no longer available, it seems logical to turn to Texas' other abundant fossil fuel--lignite--to support its important petroleum, petrochemical and related industries. The degree to which lignite, rather than nuclear energy or imported coal, will fill the gap left by gas and oil will depend upon the relative costs and availability of alternature fuels. The balance struck between these other fuels and lignite in competing for Texas markets will, therefore, ultimately determine the scale and location of the environmental impacts experienced by the state as a result of developing its lignite resource.

A host of economic and political factors will influence the continuing trade-off between coal and lignite. These factors, discussed at greater length in Chapter Five, fall into several categories:

- Availability of coal, as influenced by rail capacity, policies concerning interstate slurry pipelines, leasing of federally held coal, and implementation of the new Surface Mining Control and Reclamation Act of 1977.

- Relative economics of sulfur removal and emission control under the provisions of the new Clean Air Act Amendments of 1977.

- Policies concerning natural gas production, pricing, and allocation, which will largely determine whether the vast deep-basin lignite resource is developed.

- Environmental and economic constraints on mining lignite and siting lignite-using plants.

- Legal and institutional constraints.

Many of these factors are fluid and uncertain at present. Nevertheless, for convenience in discussing the potential impact of lignite development, some sort of forecast is necessary. Consequently, an "envelope," rather than a series of curves, has been developed, as described below. Impacts will be discussed in terms of the upper and lower bounds of the envelope. It should be understood that the envelope does not represent a continuous gradation of possible futures. Because the factors listed above depend mainly on discrete, independent government policies, the envelope actually bounds a series of discontinuous curves, reflecting the various combinations of these policies. A detailed examination of these combinations is outside the scope of the present study. A more thorough treatment would certainly be necessary for any impact assessment intended as a framework for actual planning. Pending the action of Congress on several outstanding pieces of legislation, such a study is strongly recommended.

2.4 Lignite Development Forecast

An ideal forecast of lignite development would incorporate demand components for electrical generation, on-site power generation for industry, process heat and steam, and feedstocks. Of these, the needs of electricity can be predicted most effectively, since the fuel conversion patterns of utilities are well known and quite uniform. By comparison, very little detailed data on fuel use patterns in other industries are available. Furthermore, these patterns are very complex (for example, natural gas used in olefin plants is first "stripped" of some of its components, which are used as a feedstock; coal or lignite could not be directly substituted into this system). Variability between individual installations is also great, which further limits accurate prediction of how much lignite could--and would--be used.

A few rough industrial demand estimates have been published. These range from 54 million short tons (MST) per year of both coal and lignite in 1985 and 142 MST in 1990, assuming complete phaseout of natural gas as a fuel (WH-124). Petrochemical feedstock demand is even less predictable. While it can be said with certainty that at least some of the future industrial fuel demand will be met by lignite, it is by no means certain that any lignite will be used as a feedstock by 2000. Not only economics, but regulatory policies, will have a controlling impact on this component of demand, as is discussed in detail in Chapter Five.

Under these circumstances, no attempt was made to forecast industrial and feedstock demand, because of the degree of uncertainty surrounding them. Consequently, all quantitative discussions that follow in Chapters Four and Five will be based on the use of lignite by utilities alone. While power generation will undoubtedly be the largest user of lignite for many years, this should not be construed to imply that other uses are negligible. The reader should bear in mind that industrial uses probably fall in the same order of magnitude and that cumulative impacts could be significantly increased by this additional demand factor.

A number of electricity demand forecasts for the State of Texas have recently been made (HO-400; TE-301; BA-560). The projections of the Texas Water Development Board (TE-301) have been chosen as the basis of the present study, since they attempt to take into account several of the factors actually influencing demand growth, rather than using a simple overall growth rate. Some interpretation has been applied to the Board's figures to produce a forecast of lignite growth alone.

The Board based its power demand projections on consideration of actual announced developments, future population growth, and changing per-capita consumption of electricity. Three forecasts were produced, extending to the year 2030. All the forecasts follow official announcements for the period 1977 to 1985; since the lead time necessary to put a lignite-fired plant on line is roughly seven years, this segment of the forecasts is likely to remain fairly correct, even if the demand picture changes radically.[1] The high- and medium-demand forecasts use the power industry's linear extrapolations of the curve for the 1975-1985 decade to project the next decade, to 1995. The two forecasts differ in that the medium forecast assumes that per-capita consumption rates stabilize after 1995. The low forecast assumes no increase in per-capita consumption rates after 1985, leaving population growth the controlling factor from that point on. Population figures used by the Board are presented in Table 2.4-3, and reflect regional demographic trends and economic prospects on a county-by-county basis (TE-301).

TABLE 2.4-3

PROJECTED TEXAS POPULATION, 1980-2000
USED AS BASIS FOR POWER DEMAND PROJECTIONS

Year	Projected Population	Percent Change 10-Year Period
1980	13,400,000	19.6
1990	15,594,000	16.4
2000	18,276,000	17.2

Source: TE-301

---

[1] Figure 2.4-1 shows the location of all present and announced lignite-fired stations for which sites are known. Tables 2.4-1 and 2.4-2 list the capacities, schedules, and owners/operators of these plants and the associated mines, respectively.

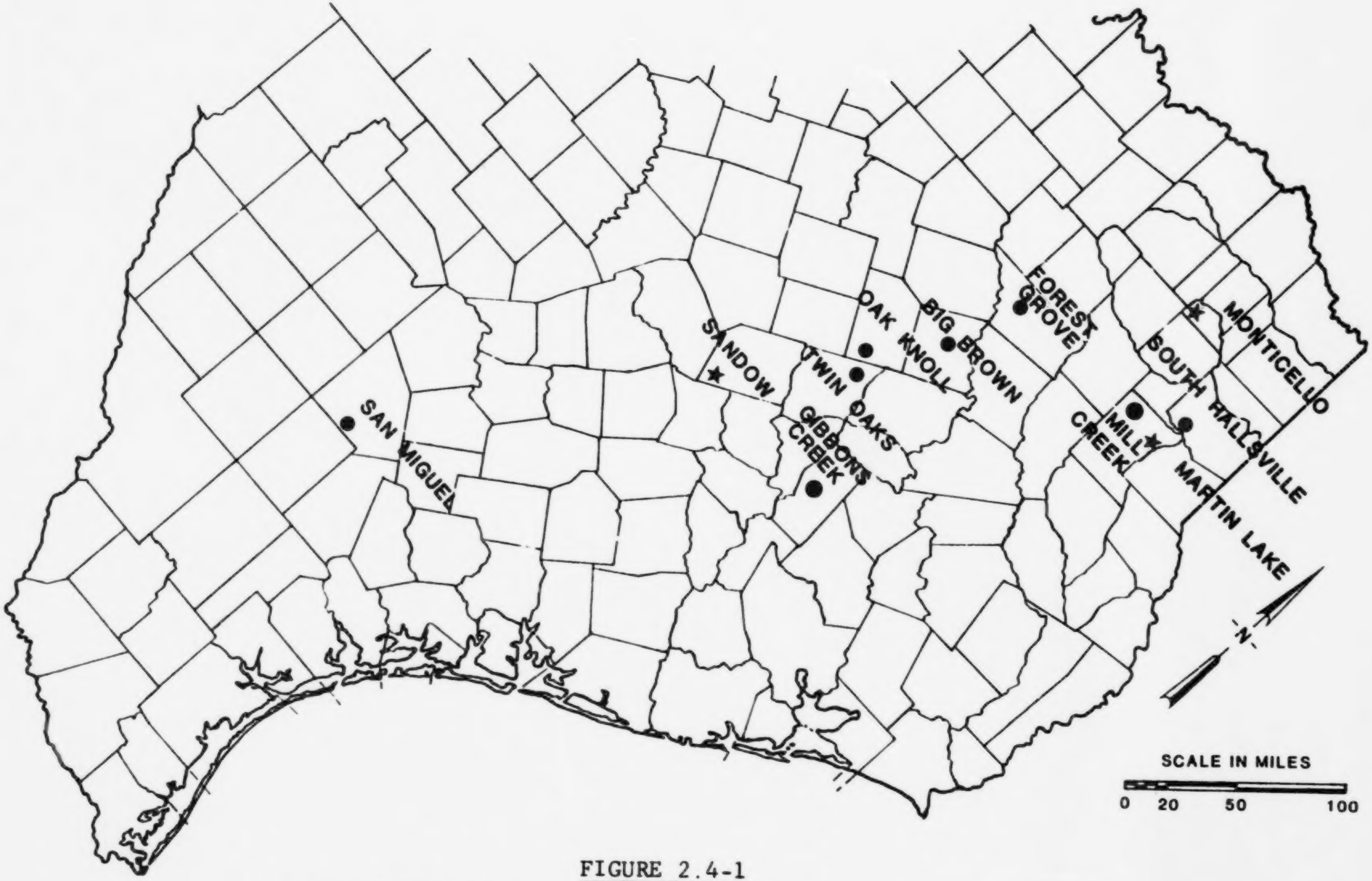

MONTICELLO
SOUTH HALLSVILLE
MARTIN LAKE
MILL CREEK
FOREST GROVE
BIG BROWN
OAK KNOLL
TWIN OAKS
GIBBONS CREEK
SANDOW
SAN MIGUEL
N
SCALE IN MILES
0 20 50 100

FIGURE 2.4-1

PRESENT (★) AND PLANNED (●) LIGNITE-FIRED MINE-MOUTH POWER PLANTS

02-1979-1

TABLE 2.4-1

LIGNITE GENERATION PLANTS

Year of Start-Up	Plant Name	mw	Operator
	Lignite		
1976 and earlier	Sandow #1, 2 & 3	360	Texas Power and Light/Alcoa
	Big Brown #1 & 2	1150	Texas Utilities Services, Inc. (TUSI)
	Monticello #1 & 2	1150	TUSI
1977	Martin Lake #1	750	TUSI
1978	Monticello #3	750	TUSI
	Martin Lake #2	750	TUSI
1979	Martin Lake #3	750	TUSI
	San Miguel #1	400	South Texas and Medina Electric Co-op
1980			
1981	Sandow #4	545	Texas Power and Light/Alcoa
	Gibbons Creek #1	400	Texas Municipal Power Pool
1982	Forest Grove #1	400	TUSI
1983	Martin Lake #4	750	TUSI
1984	San Miguel #2	400	STM Electric Co-op
	Twin Oak #1	562	Texas Power and Light
	LCRA*	750	
	South Hallsville	660	Southwest Electric Power
1985	Twin Oak #2	562	Texas Power and Light
	Gibbons Creek #2	400	TMPP

*Plant name and location not yet assigned.

SOURCE: WH-124

TABLE 2.4-2

PROJECTED LIGNITE PRODUCTION FOR POWER GENERATION BASED ON INDUSTRY ANNOUNCEMENTS (Million Tons Per Year)*

	1977	1978	1979	1980	1981	1982	1983	1984	1985	Full
Freestone County TU--Big Brown	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Grimes County TMPP--Gibbons Creek					2.7	2.7	2.7	2.7	5.4	5.4
Harrison County SWEP--South Hallsville								3.0	3.0	6.0
Henderson County TU--Forest Grove					1.0	3.8	3.8	3.8	3.8	3.8
Limestone County TU--Oak Knoll										7.0
McMullen County STM--San Miguel			1.0	2.7	2.7	2.7	2.7	3.7	5.4	5.4
Milam County TU--Rockdale	2.0	2.0	2.0	2.0	4.8	4.8	4.8	4.8	4.8	4.8
Panola County TU--Martin Lake	4.5	8.0	11.5	11.5	11.5	12.5	14.0	14.0	14.0	14.0
Robertson County TU--Twin Oaks							1.0	4.5	7.0	7.0
Rusk County TU--Mill Creek										7.0
Titus County TU--Monticello	6.0	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Total	17.9	25.0	29.5	31.2	37.7	41.5	44.0	51.5	58.4	75.4

TU--Texas Utilities
TMPP--Texas Municipal Power Pool

SWEP--Southwest Electric Power
STM--South Texas and Medina Electric Co-op

*Assumes 75% capacity factor, 10,400 Btu/kwh, and lignite heat content typical for location of plant.

SOURCE: WH-124

The low forecast was chosen for this study, based on a feeling that higher prices and advances in energy-saving technology will tend to curtail growth in per-capita electrical energy consumption. The Board broke out its statewide totals into component river basins and basin segments, based on the assumption that the present relative production of power between them prevails throughout the forecast period. From these figures a composite was derived of total power production in all those basin units which could be served by lignite. Figure 2.4-2 shows the geographical extent of this somewhat arbitrary area.

To arrive at a forecast of the proportion of this total power output that might be fired by lignite, it was first assumed that in 1990, 15 percent would come from nuclear power and 10 percent from gas and oil, and that by 2000 only 5 percent would still be gas-fired and 15 percent would be nuclear power.[1] These estimates are purely subjective and are loosely based on the amount of nuclear capacity currently planned for Texas, expected to grow moderately due to the limited availability of uranium and uncertainty over the availability of other fuels. Although present federal policy strongly favors phasing out all natural gas in industry and utility boilers, it is felt that there will be some exemptions made for peaking units. Also, the practical difficulty of tying down fuel supplies needed for the short-term, massive conversion required in Texas will probably force some utilities to continue using gas after 1985, even if faced with economic penalties.

Up to now, a fifty-fifty split in the Texas utility market has been envisioned between lignite and western, low-sulfur coal. However, the recently enacted Clean Air Act Amendments

---

[1] Although most projections give nuclear a larger than 15% share by 2000, this conservative estimate reflects the growing uncertainty over such items as the licensing and cost of plants, fuel costs, waste disposal, and nuclear proliferation in general.

Reproduced from best available copy.

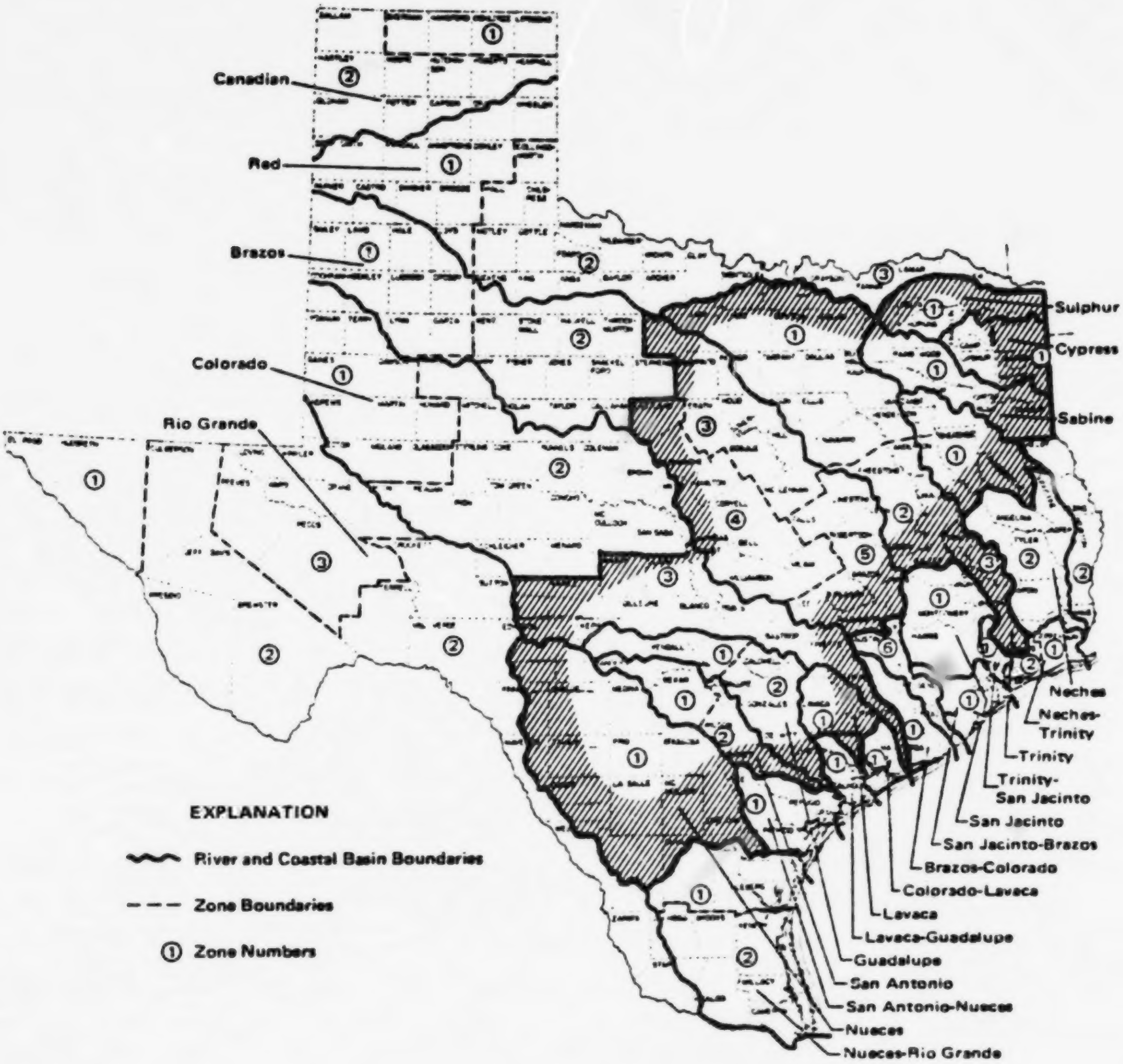

Canadian
Red
Brazos
Colorado
Rio Grande
Sulphur
Cypress
Sabine
Neches
Neches-Trinity
Trinity
Trinity-San Jacinto
San Jacinto
San Jacinto-Brazos
Brazos-Colorado
Colorado-Lavaca
Lavaca
Lavaca-Guadalupe
Guadalupe
San Antonio
San Antonio-Nueces
Nueces
Nueces-Rio Grande
EXPLANATION
River and Coastal Basin Boundaries
Zone Boundaries
① Zone Numbers

FIGURE 2.4-2

RIVER AND COASTAL BASINS AND ZONE DELINEATIONS SHOWING AREA POTENTIALLY SERVICE BY LIGNITE-GENERATED ELECTRIC POWER

(SOURCE: TE-301)

and the Department of Interior's "short-term criteria" for leasing federal coal both suggest a sharp increase in demand for Texas lignite.[1] Figure 2.4-3 presents an envelope of lignite demand for the years 1985-2000. This envelope is bounded by the two extremes of zero coal imports and fifty-fifty sharing, reflecting these recent developments. When regulations and implementation strategies for the new clean air and leasing policies are developed, a certain amount of competition from non-federal western and perhaps midwestern coals will pull the curve away from the upper limit. Furthermore, consumption at this rate would consume virtually all of the present strippable lignite resources, using the most generous estimates, by 2030. Universal requirements for "best available control technology" (BACT) to control sulfur emissions--scrubbers, fluidized-bed combustion, or coal-cleaning--will probably continue to favor lignite over western coal. Thus, the half-and-half distribution prevailing in currently planned new generating capacity may never again be realized.

The cumulative demand for lignite to 1985 was calculated on the basis of announced plants, and thereafter on the basis of 6,000 tons per year per MWe. The conversion factor is based on an average of the ratios of fuel input to power output for nine announced plants, covering the full range of lignite characteristics (WH-124). Table 2.4-4 summarizes both power generation and mine output for the year 2000 and indicates the number of new, 1500 MWe generating stations that correspond to those forecasts. This station size reflects current planning, and consists of two side-by-side 750 MWe units, operating at 60 percent load capacity. (This capacity was assumed by the Texas Water Development Board, based on historical operating experience, and is carried over into this forecast.)

---

[1] A more detailed discussion of these policies is found in Chapter Five.

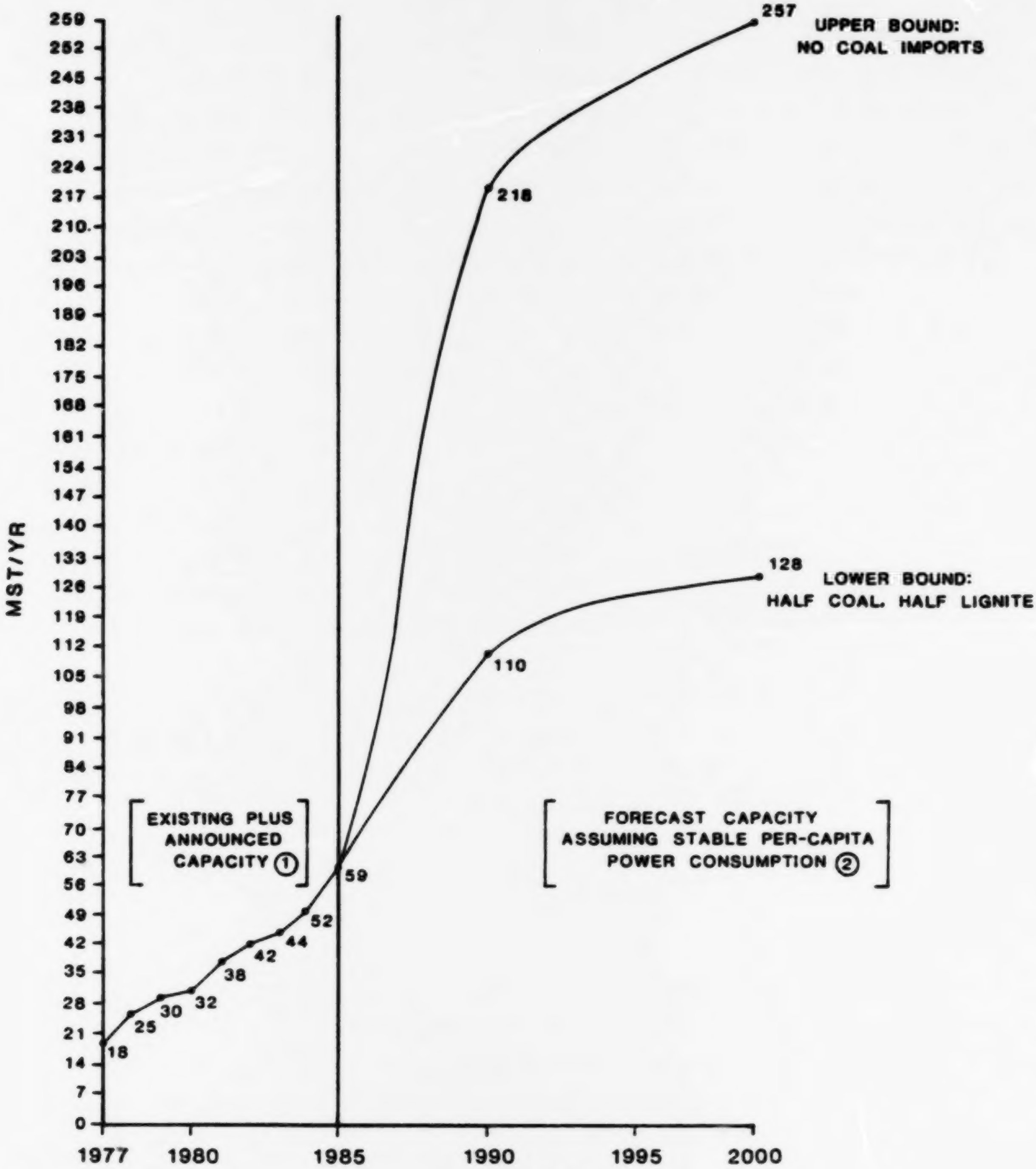


FIGURE 2.4-3

POTENTIAL RANGE OF LIGNITE CONSUMPTION BY UTILITIES

① Lignite consumption based on known quality of lignite in site area

② Lignite consumption based on average of 6,000 tons/MWe

	Existing and Planned, to 1985			Additional Growth			Total in Year 2000		
	Generating Capacity	No. Of Stations	Yearly Lignite Production	Generating Capacity	No. Of Stations	Yearly Lignite Production	Generating Capacity	No. Of Stations	Yearly Lignite Production
Upper Bound	10,739 MWe	9	59 MST	32,061 MWe	21	198 MST	42,800 MWe	30	257 MST
Lower Bound	10,739 MWe	9	59 MST	10,661 MWe	7	69 MST	21,400 MWe	16	128 MST

TABLE 2.4-4

SUMMARY OF FORECAST LIGNITE USE BY UTILITIES

3.0 ENVIRONMENTAL SETTING

3.1 Human Components

The purpose of this section is to present a brief cultural overview of the Texas lignite belt. Emphasis is on those cultural features which may be important considerations in future lignite development.

A macro-regional approach has been adopted since such a large area is being considered. This approach emphasizes the geographical variation of cultural factors within the region. The lignite of Texas is in 66 contiguous counties; however, to sufficiently show the variation, a 124-county area encompassing most of East and South Texas has been adopted. This is necessary because the important features of the region become obvious only when examined from this broader perspective.

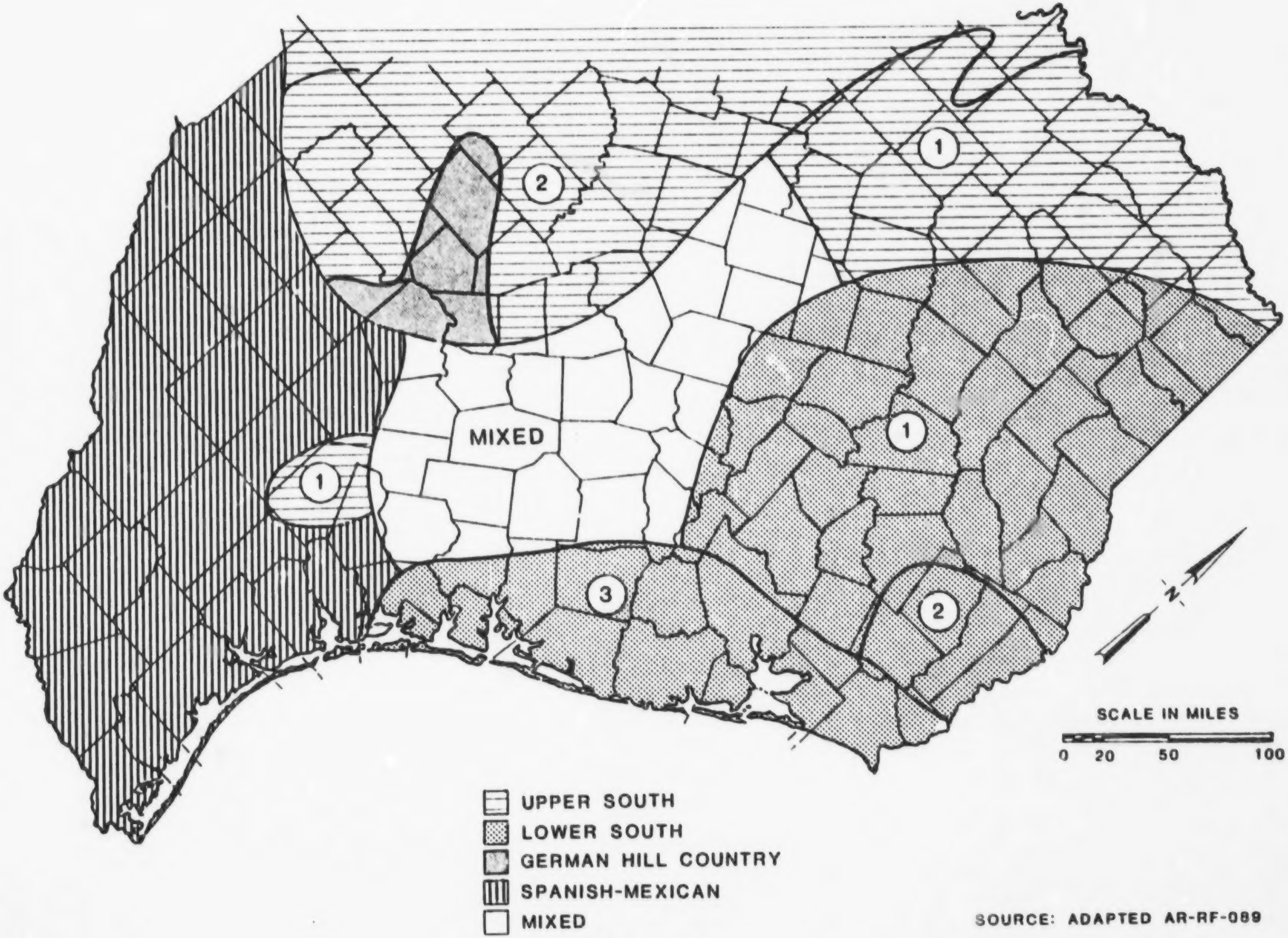
3.1.1 Population

Historical Trends

Texas is a rapidly growing area with substantial in-migration from other states and countries. However, the process of in-migration has been in progress throughout the area's history. An examination of the origins of the early in-migrants give considerable insight into the present cultural variation of the study area.

Figure 3.1-1 shows the traditional cultural patterns which evolved in the nineteenth century in East and South Texas (JO-257, JO-258, JO-259, ME-189). Eastern Texas was colonized by at least four distinct groups coming from different directions. From the south came the Spanish and Mexican influx. From overseas came Europeans who settled in the "German Hill Country" and the area marked

Preceding page blank


1
2
MIXED
1
1
3
2
N
SCALE IN MILES
0 20 50 100
UPPER SOUTH
LOWER SOUTH
GERMAN HILL COUNTRY
SPANISH-MEXICAN
MIXED

SOURCE: ADAPTED AR-RF-089

FIGURE 3.1-1

CULTURAL PATTERNS IN THE 19TH CENTURY

02-1724-1

"Mixed." From the east (Louisiana, Mississippi, etc.) came the "Lower South" element, while from the northeast (Missouri, Arkansas, Tennessee, etc.) came the "upper South" element.

The Spanish-Mexican region still has a distinctive Latin influence, but it has been moderated by years of "Americanization." The German Hill Country retains a Teutonic character, especially in its architecture. Settlers of that area came from Europe just as did immigrants to the "Mixed" region of Central Texas. In the "Mixed" region, Europeans and settlers from the Upper and Lower South were dominant.

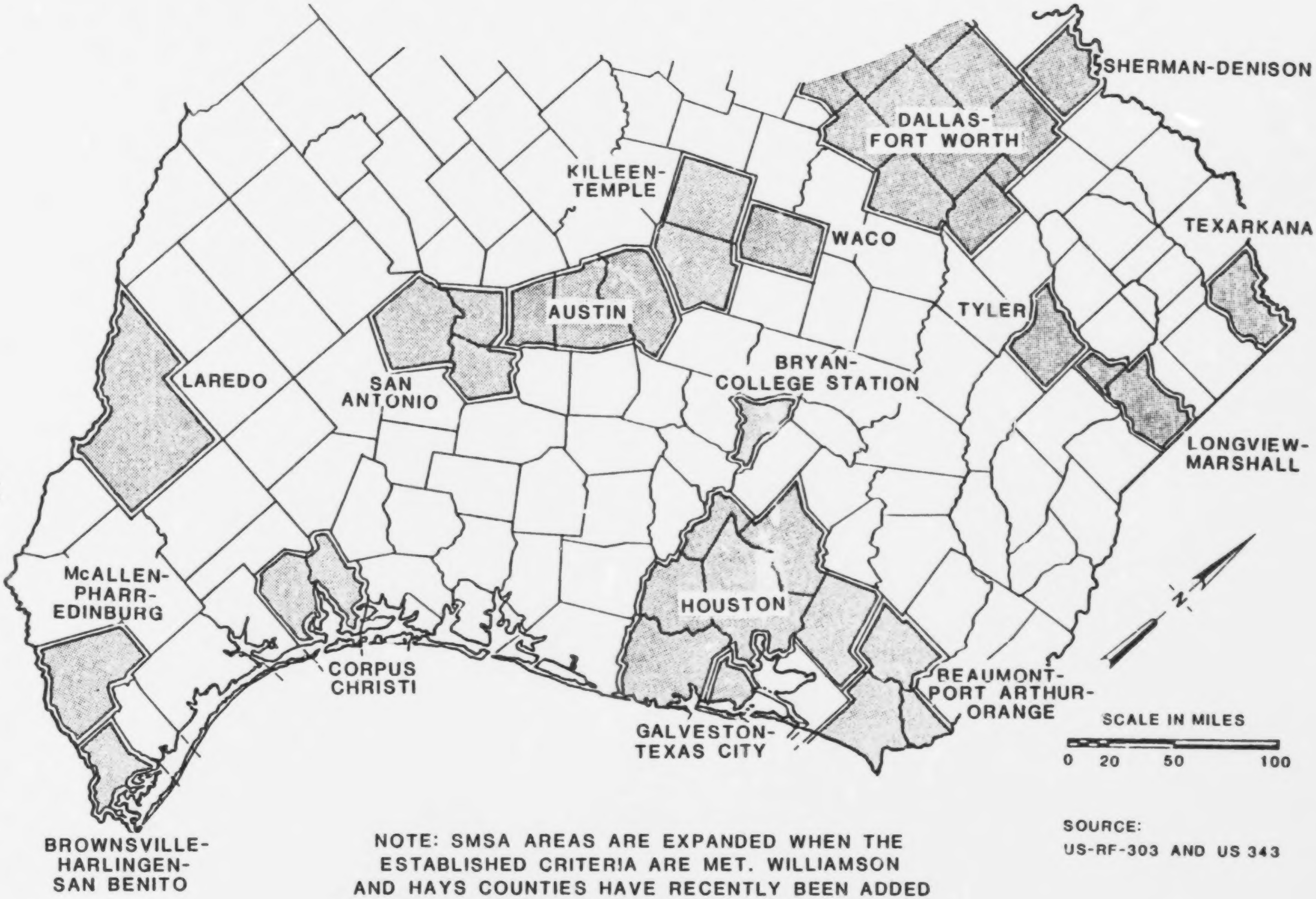
The Upper South area marked "1" was settled by middle-class white southerners who engaged in market-oriented cotton and grain farming. The area labelled "2" was strongly influenced by Appalachian hill folk who engaged in subsistence agriculture.

The Lower South area had three major components. Area "1" was a continuation of the plantation aristocracy with large numbers of rural blacks and a dependence upon cotton farming. Area "2" had mostly poor whites and subsistence agriculture. The area marked "3" was a blend of the plantation aristocracy from Louisiana and foreign immigrants.

Today's socioeconomic characteristics strongly reflect those nineteenth century settlement trends.

Contemporary Trends

The clusters of high population density are associated with the metropolitan areas (Figure 3.1-2). Obviously, Dallas/Ft. Worth and Houston are the major centers. However, the urbanized strip from San Antonio northeast to Waco is also very dense. What is critical to this study is the relatively low population density which characterizes the lignite belt.


SHERMAN-DENISON
DALLAS-FORT WORTH
KILLEEN-TEMPLE
WACO
TEXARKANA
AUSTIN
TYLER
LAREDO
SAN ANTONIO
BRYAN-COLLEGE STATION
LONGVIEW-MARSHALL
McALLEN-PHARR-EDINBURG
HOUSTON
N
CORPUS CHRISTI
BEAUMONT-PORT ARTHUR-ORANGE
SCALE IN MILES
0
20
50
100
GALVESTON-TEXAS CITY
BROWNSVILLE-HARLINGEN-SAN BENITO

SOURCE:
US-RF-303 AND US 343

NOTE: SMSA AREAS ARE EXPANDED WHEN THE ESTABLISHED CRITERIA ARE MET. WILLIAMSON AND HAYS COUNTIES HAVE RECENTLY BEEN ADDED TO THE AUSTIN SMSA. SIMILAR SITUATIONS MAY EXIST.

FIGURE 3.1-2

STANDARD METROPOLITAN STATISTICAL AREAS (SMSA)

02-1723-1

Probably more than any other factor, the lack of massive metropolitan development in the Texas lignite is critical to the future of the region. This location of this environmentally sensitive resource between major metropolitan centers is important to critical impact and policy analysis.

The lignite belt was not a dramatic growth region in the 1960's, especially in the central and southern portions. The northern portion experienced moderate growth because of the rise of its small metropolitan center (Tyler/Longview), with the accompanying industrial diversification that occurred in that period. Since 1970, there has been a somewhat surprising resurgence of nonmetropolitan areas, not only in Texas, but throughout the United States (BE-431). Most of the lignite belt has experienced net in-migration since 1970, reversing the net out-migration of the previous three decades.

Several generalizations can be made regarding future population growth in the 124-county region. First, the counties surrounding large urban centers will experience considerable growth. For instance, the counties contiguous to Harris County (Houston) will grow through in-migration. Second, nonmetropolitan counties with access to metropolitan employment and services will grow through in-migration. This includes most of East Texas, but little of South Texas. Third, there is evidence that very large cities may not continue to grow in the near future (BE-431). For instance, Dallas and Tarrant Counties both experienced net out-migration from 1970 to 1974 (US-632). Smaller metropolitan centers will be the growth areas of the near future. Finally, population projections for Texas are of limited value because the state is changing so rapidly. Projections based upon historical trends cannot reflect unknowns such as energy development in rural areas. For this reason, no population projections are presented.

Contemporary Chracteristics

The "historic trends" section reflects current ethnic and racial patterns in the study area. The study area is multi-ethnic/racial in character. Spanish-surnamed people (mostly Mexican-Americans in Texas) are dominant in the southern areas. Just as distinctive, although not as extensive, is the large black population in East Texas counties where plantation agriculture from the "lower South" was important in the nineteenth centure.

The area with a high proportion of Spanish-surnamed has a low median age. However, in areas with large percentages of blacks the median age is relatively high because large numbers of young blacks in these counties migrated to metropolitan centers in the 1950's and 1960's. In general, the population of the lignite belt north of the Colorado River is relatively old compared to the state median (26 years) and has a low percent in the younger age groups. The area south of the Colorado River is vastly different, with its young, predominantly Mexican-American population.

The entire Texas lignite belt is characterized by a high incidence of poverty and low education levels. The nonmetropolitan lignite belt of Texas is a relatively depressed area when compared to the metropolitan areas to the southeast (Houston, Beaumont, etc.) and the west (San Antonio to Sherman). This underdevelopment of human resources may be critical to the future of the area.

3.1.2 Economic Structure

As indicated above, the population of the entire lignite belt has a high incidence of poverty[1] with respect to the surrounding metropolitan areas, and poverty increases along a line from Northeast Texas to South Texas. Many factors are highly correlated to these trends, with industrial structure being one important consideration.

---

[1] As defined by the U.S. Bureau of the Census (US-343), based on income level.

The lignite belt is relatively low in employment in the service sector (service, trade, finance, insurance, real estate, government, utilities, etc.). The service sector is critical to economic prosperity.

In addition, the economy of the lignite belt is relatively low in manufacturing employment (SIC 19 to 39), especially when compared to the large metropolitan areas surrounding the region. The obvious exception is the Longview-Tyler-Marshall area of Northeast Texas, where manufacturing employment is higher.

Thus, the lignite belt relies heavily upon agriculture and extractive industries. Oil and natural gas are produced in nearly every county in the lignite belt with a notable concentration in the northeast. Agriculture is still extremely important, especially in the Blackland Prairie region of Central Texas. The employment in agriculture in the East Texas areas near Louisiana has declined in recent years, showing the relatively poor potential of that area for row crops. Both crops and livestock are important sources of revenue throughout the 124-county region, although the area near Louisiana is decreasing in productivity. The Rio Grande Valley and South Texas are very dependent upon irrigated agriculture.

Crop patterns have changed dramatically in the 20th century. Texas cotton production since 1900 has shifted from the Blackland Prairie region of Texas to the High Plains, with the advent of irrigation. Yet, cotton is still an important crop to the region. Grain sorghum, which has been replacing cotton in many areas, is most important in the area south of the original Texas cotton belt.

The peanut is of particular importance to the lignite belt in that it is perhaps the only row crop that might compete with surface mining for the sandy soil that overlies the Wilcox formation lignite. Hay is the other possibility.

Since hay and pasture are widespread throughout the lignite belt, and since grain sorghum and corn are locally available, cattle production is important to the economy. In fact, probably the most significant agricultural trend in the lignite belt has been the growing importance of cattle production.

One last aspect of agriculture is the timberlands of East Texas. For the most part, the lignite belt vegetation consists of species not now vital to Texas forest industries. However, part of the lignite region extends into the Pineywoods of East Texas where timber is a valuable resource.

A final important measure of the economy is unemployment. The region north of the Colorado River has relatively low unemployment rates, while fairly extensive areas of South Texas have extremely high rates. The portion of the lignite belt north of the Colorado River has no large, significant pockets of unemployment. However, the entire State of Texas is experiencing relatively low unemployment since Texas' economy is currently strong. Also, the excess labor of the lignite belt, which might now be unemployed, migrated from the region in the 1950's and 1960's so that stable employment characterizes the region today.

3.1.3 Land Use

Land use in the lignite belt is closely related to the quality of the soils and the availability of other natural resources. For instance, the soils of the Blackland Prairie region to the west of the lignite belt in Central Texas is extremely productive. Consequently, it is almost completely cultivated (cotton and sorghum predominantly). Scattered through that region are agricultural service towns.

The Post Oak Savannah region, which covers the central portion of the lignite belt, is less productive in crop yields. Much former cropland has been allowed to go fallow. That region has recently experienced a large rise in the acreage devoted to Coastal Bermuda for improved pasture. East of the Post Oak Savannah region is the East Texas Pineywoods region. Relatively low acreages in that area are devoted to crops. Natural resource extraction (lumbering, oil, and gas) is an important land use in this far East Texas area.

The Coastal zone from the Louisiana border to the Corpus Christi area is a productive area agriculturally, with a large acreage in rice, soybeans, and grain sorghum. A dominant feature of this region is the Houston-Galveston-Beaumont metropolitan area with expanding residential, commercial, and industrial land uses. Interspersed all along the Texas cost from Beaumont to Corpus Christi are refining and petrochemical industries and oil and gas extraction activities.

Far South Texas is an arid zone with relatively unproductive soils. The land has a low carrying capacity, so the population is low. Range land for cattle and mineral extraction are the notable land uses. An exception is the Rio Grande River Valley, where intensively cultivated, irrigated crops of a wide variety are grown. However, nearly all irrigated agriculture in South Texas occur beyond the lignite belt.

The problems associated with controlling expanding metropolitan land use exist only in the northeast portion of the lignite belt. The Tyler-Longview-Marshall area is merging into one continuous metropolitan area functionally linked by commuting and economic interdependence. Controlling undesirable land use trends such as rural "scatterization" (low density tract developments) may already be a problem for that region.

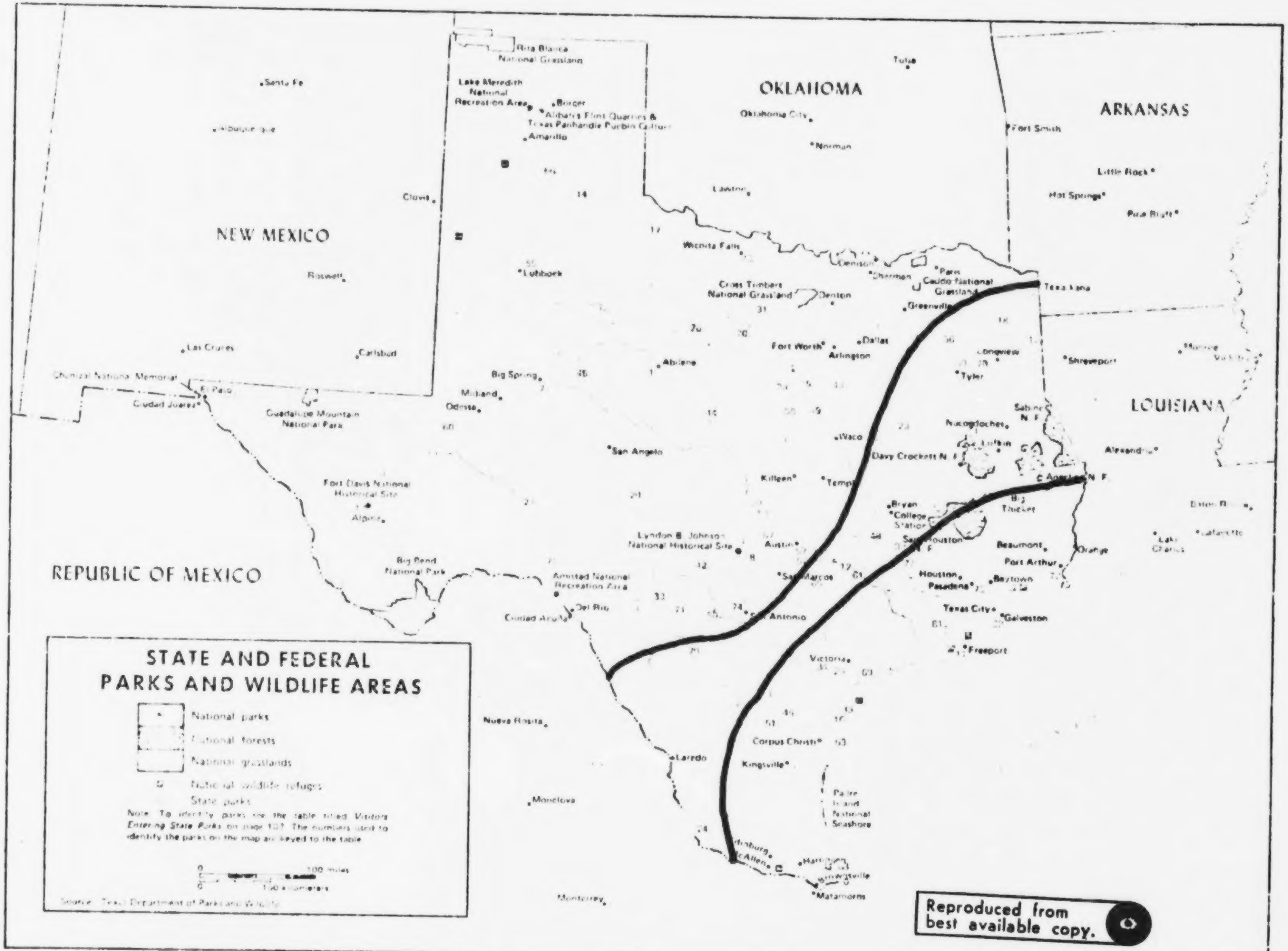
A much more thorough treatment of land use on and near the lignite belt will be important as a planning tool as development increases.

3.1.4 Infrastructure and Recreational Resources

Included in the classification "infrastructure" are those systems or mechanisms by which society serves its aggregate needs. Hence, concern is with those facilities and services which all people use, and which have such high costs that collective payment (taxes and/or fees) is required.

Recreational facilities of major concern are the large areas such as state and national parks and wildlife refuges (Figure 3.1-3). There are many of these facilities in East and South Texas. Both Davy Crockett and Angelina National Forests are underlain by potential lignite deposits, as is Bastrop State Park. Particularly noteworthy are the national forests of East Texas. Also important as recreational resources are the many lakes and reservoirs of the entire 124-county area.

Some 230 National Register Historic Sites are located in the 124-county region. However, the bulk of these are in the metropolitan areas outside the lignite belt, such as Austin and San Antonio. Fayette County (8 sites), Gonzales County (5 sites), and Marion County (15 sites) have the highest numbers of National Register sites within the lignite belt.


STATE AND FEDERAL
PARKS AND WILDLIFE AREAS
National parks
National forests
National grasslands
National wildlife refuges
State parks
Note: To identify parks see the table titled Visitors Entering State Parks on page 107. The numbers used to identify the parks on the map are keyed to the table.
0 100 miles
0 150 kilometers
Source: Texas Department of Parks and Wildlife
NEW MEXICO
OKLAHOMA
ARKANSAS
LOUISIANA
REPUBLIC OF MEXICO
Santa Fe
Albuquerque
Clovis
Roswell
Las Cruces
Carlsbad
Chamizal National Memorial
El Paso
Ciudad Juarez
Guadalupe Mountain National Park
Fort Davis National Historical Site
Alpine
Big Bend National Park
Rita Blanca National Grassland
Lake Meredith National Recreation Area
Borger
Alibates Flint Quarries & Texas Panhandle Pueblo Culture
Amarillo
Lubbock
Big Spring
Midland
Odessa
San Angelo
Abilene
Wichita Falls
Lawton
Oklahoma City
Norman
Tulsa
Fort Smith
Little Rock
Hot Springs
Pine Bluff
Cross Timbers National Grassland
Denton
Denison
Sherman
Paris
Caddo National Grassland
Greenville
Texarkana
Fort Worth
Arlington
Dallas
Longview
Tyler
Shreveport
Monroe
Waco
Nacogdoches
Sabine N.F.
Lufkin
Davy Crockett N.F.
Angelina N.F.
Alexandria
Killeen
Temple
Bryan
College Station
Big Thicket
Sam Houston N.F.
Beaumont
Port Arthur
Orange
Lake Charles
Lafayette
Baton Rouge
Lyndon B. Johnson National Historical Site
Austin
San Marcos
San Antonio
Houston
Pasadena
Baytown
Texas City
Galveston
Freeport
Amistad National Recreation Area
Del Rio
Ciudad Acuña
Victoria
Corpus Christi
Kingsville
Padre Island National Seashore
Laredo
Nueva Rosita
Monclova
Monterrey
Edinburg
McAllen
Harlingen
Brownsville
Matamoros

Reproduced from best available copy.

FIGURE 3.1-3

PARKS AND RECREATION LANDS

The Texas lignite belt is not well served by highways, especially in its Central Texas portion. Interstate highways connect the three corners of a triangle made up of San Antonio, Houston, and Dallas. However, highways to these three cities from within the triangle, a major portion of the lignite belt, are neither as direct nor as good. This is a by-product of the area's relatively sparse population. Northeast Texas has somewhat better connections with major metropolitan areas via interstate highway, reflecting the higher population density.

By contrast, rail transportation is a positive feature of the lignite belt. The entire region is crisscrossed by numerous lines giving this area access to major regional centers and Gulf Coast ports. The nearest port facilities are in the Houston-Beaumont area. Major commercial airlines serve Houston, Dallas, San Antonio, and Austin. The smaller metropolitan centers (Waco, Longview, Texarkana) have only limited commercial airline service.

The number of people per physician in the lignite belt is higher than in surrounding metropolitan counties. This is not to say that health care in those areas is deficient. It appears rather that many people of the lignite belt drive to the metropolitan areas for medical services and hospital care.

Suitable housing is normally in short supply in non-metropolitan areas as reflected in a recent study in Milam County by Radian. Few rental units are usually available and most unanticipated growth has to be accommodated in mobile homes.

Many educational facilities in the lignite belt--particularly some rural school districts of the region--may now be experiencing problems in terms of quantity and quality of educational resources.

The same can be said about municipal services and facilities in the lignite belt. Already, many areas have sewerage systems in need of upgrading and/or expansion. Sewage systems in other areas might violate water quality and effluent standards if sudden population growth took place.

In general, the demand for public services and facilities is low in the lignite belt because of the small size of the population. Likewise, the supply is limited to the essentials, such as water, sewers, police, and fire protection. The economies of scale of metropolitan centers, which are necessary for expansion, do not appear to be operating in the lignite belt. Hence, a thorough analysis of the existing facilities and services would be an important tool in planning for increased lignite development.

3.2 Physical Components

3.2.1 Climate and Air Quality

Climatic Characterization

The climate throughout the Texas lignite belt is humid and subtropical with hot summers and mild winters. Precipitation occurs mostly in the form of showers and thundershowers. Extended periods of light rain or drizzle, however, do occur during the winter months.

Precipitation amounts vary significantly throughout the Texas lignite belt. The southern portion of the lignite belt (Webb, Zapata, and Starr Counties) receives only 18 inches on an annual basis, while the northeast portion (Jasper and Newton Counties) receives 54 inches. September and May are the rainiest months throughout most of the area, while January, March, and July are the driest.

The average annual temperature throughout the lignite belt is 69°F, ranging from 74°F in the southern portions to 66°F in the northeastern portions. Although extended periods of below-freezing weather are uncommon, freezing temperatures are recorded an average of 25 times during the year in the northeastern portion of the lignite belt.

Drought conditions are not altogether uncommon in the study region. A region can be arbitrarily noted as undergoing drought conditions whenever the region experiences 75 percent or less of the normal rainfall during the year. The highest frequency of drought conditions occurs along the extreme southern portions of the lignite belt and over the southwestern portion (Edwards Plateau). Throughout these two regions, the drought frequency is 18 percent. This means that drought conditions occur in 18 percent of the years of record. The lowest drought frequency, 12 percent, occurs in the northeastern portion of the study region.

Although the drought frequency over the southern portion of the lignite belt and the frequency over the southwestern portion are the same (18 percent), the duration of droughts varies. The southern portion has numerous droughts of short duration while the southwestern portion has less numerous but longer lasting droughts.

The mean annual lake evaporation ranges from 51 inches in Jasper and Newton Counties (northeastern region of the lignite belt) to 77 inches in Maverick County (southwestern portion of the lignite belt). Throughout most of the study region, the mean annual lake evaporation exceeds the annual rainfall.

One of the important factors to consider in the assessment of the surface reclamation potential of the Texas lignite belt is the frequency of occurrence of desiccating or drying conditions. Desiccating conditions occur during the combined presence of low relative humidity, high temperatures, and high winds. During these harsh conditions, the increase in the rate of evapotranspiration from plant surfaces cannot be matched by the rate water is taken up through the root system. Consequently, wilting can take place even though adequate moisture is present in the soil. The highest potential of desiccating conditions in the lignite belt occurs in the Maverick-Zavala-Dimmit County region of South Texas. Conversely, the lowest potential for desiccating conditions occurs in the Jasper-Newton County region of Northeast Texas.

The Texas lignite belt has an average growing season of 275 days, ranging from 235 days in the northeastern portion to 305 days in the southmost region (Starr County). This growing season is defined as the number of days between the last freeze in the spring and the first freeze in the fall. (Sources for the preceeding discussion were OR-021, US-308, NA-360, and WE-225).

Existing Air Quality

The National Ambient Air Quality Standards (NAAQS), which have been established for six pollutants, are summarized in Table 3.2-1. Areas in which the NAAQS have been previously violated are classified as non-attainment areas. Areas in which the NAAQS are currently being violated extensively or areas which are projected to violate the NAAQS within the next ten years have been designated as Air Quality Maintenance Areas (AQMA's).

TABLE 3.2-1
NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS

Pollutant	Type of Standard	Averaging Time	Frequency Parameter	Concentration	
				µg/m3	ppm
Carbon monoxide	Primary and secondary	1 hr	Annual maximum[1]	40,000	35
		8 hr	Annual maximum[1]	10,000	9
Hydrocarbons (Nonmethane)	Primary and secondary	3 hr (6 to 9 a.m.)	Annual maximum	160	0.24
Nitrogen dioxide	Primary and secondary	1 yr	Arithmetic	100	0.05
Photochemical oxidants	Primary and secondary	1 hr	Annual maximum[1]	160	0.08
*Particulate matter	Primary	24 hr	Annual maximum[1]	260	--
		24 hr	Annual geometric mean	75	--
	Secondary	24 hr	Annual maximum[1]	150	--
		24 hr	Annual geometric mean	60	--
*Sulfur dioxide	Primary	24 hr	Annual maximum[1]	365	0.14
		1 yr	Arithmetic mean	80	0.03
	Secondary	3 hr	Annual maximum[1]	1,300	0.5

*Particulate and sulfur dioxide data reported here were obtained using the specified federal reference methods.

[1] Not to be exceeded more than once a year.

No ambient air monitoring data are available for the rural portions of the study area. The only monitoring data available are for the urbanized areas of Austin, Dallas, Houston, San Antonio, Mt. Pleasant, Texarkana, and Tyler. These data reflect urban conditions and are therefore not representative of the lignite belt in general. The urban measurements for 1975 shown in Table 3.2-2 list the most rural sampling data for each city in the direction nearest the lignite belt.

The Dallas and Houston Air Quality Control Regions (AQCR) are classed as non-attainment areas and also as Air Quality Maintenance areas (AQMA) for both particulates and oxidants. The San Antonio AQCR is classed as a non-attainment area for particulates. The other regulated pollutants were below federal standards at all sites except for Tyler, which exceeded the oxidant standards in 1975. The pollutant levels in the rural portion of the area are assumed to be significantly lower for all pollutants. One rural monitor for particulates in Montgomery County, Arkansas, about 75 miles from the study area, measured a maximum 24-hour concentration of 73 $\mu g/m^3$ with an annual geometric mean of 34 $\mu g/m^3$. This may be similar to background total suspended (TSP) concentrations in Texas.

3.2.2 Water Supply, Availability and Use

Surface Water

The principal river basins of the Texas lignite belt are shown in Figure 3.2-1. This area is not drained by any one principal stream, but contains portions of several basins crossing it roughly at right angles. Above the lignite outcrop area, the drainage basins of these streams are not only smaller but also receive significantly less precipitation and generally have higher evaportranspiration than in those parts of the drainage

TABLE 3.2-2

THE 1976 AMBIENT AIR QUALITY CONCENTRATIONS IN THE URBAN AREAS AROUND THE LIGNITE BELT

		Total Suspended Particulates			Sulfur Dioxide (SO_2)			Nitrogen Dioxide (NO_2)	Photochemical Oxidants
Site Location	Identification Number	Maximum 24-Hour Average	2nd Maximum 24-Hour Average	Geometric Mean	Maximum 24-Hour Average	2nd Maximum 24-Hour Average	Arithmetic Mean	Arithmetic Mean	Arithmetic Mean
Austin	45022012	193	163	60	9	2	2	28	108
Bryan	45067001	169	110	74	2	2	2	4	56
Dallas	45131002	175	161	69	19	8	2	34	39
Houston (Cypress)	45233004	166	148	62	8	2	2	23	132
San Antonio	45457036	202	96	53		2	2	24	146
Mt. Pleasant	45377001	146	103	56	96	67	6	23	150
Texarkana	45516001	194	180	99	18	14	3	25	134
Tyler	45524002	151	111	55	15	2	2	30	169

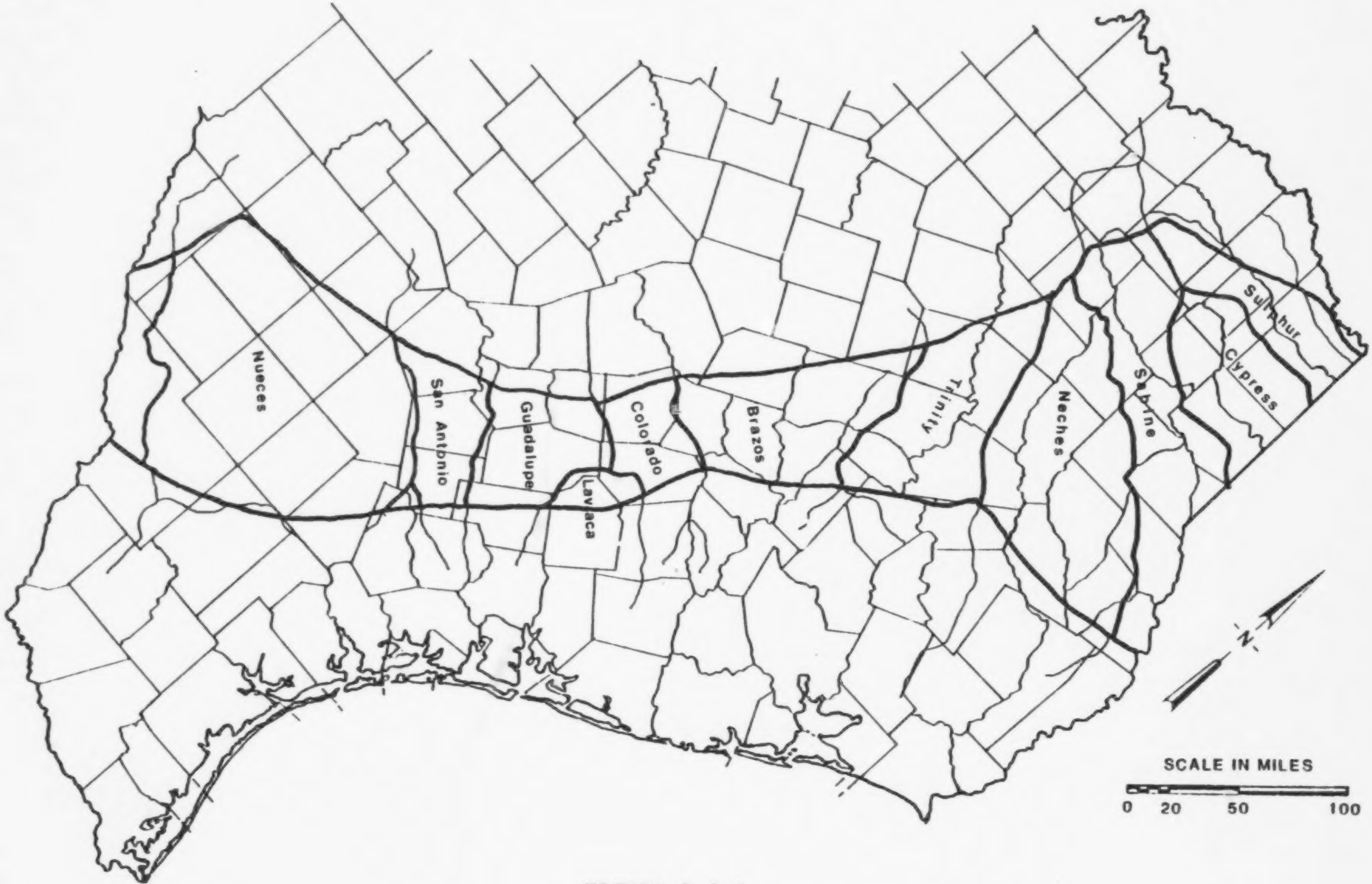

Nueces
San Antonio
Guadalupe
Lavaca
Colorado
Brazos
Trinity
Neches
Sabine
Cypress
Sulphur
N
SCALE IN MILES
0
20
50
100

FIGURE 3.2-1

PRINICIPAL RIVER BASINS OF THE LIGNITE BELT basins nearer the coast. This becomes more pronounced to the south and west, as is illustrated in the directional trend of low flows and average annual runoff from the basins (Table 3.2-3). Flood flows can occur at any time of the year on these streams but flows are generally highest in March and May. Some of the most intense point rainfalls in the United States have occurred in the general vicinity of the lignite belt, and significant flooding can take place on even small tributaries. Lower flows generally occur during August and September (TO-028).

The natural flows of these streams are without exception materially affected by upstream reservoir regulation, agricultural and municipal diversions, and return flows. Water from the two largest basins, the Brazos and Colorado Rivers, is highly regulated with very large consumptive withdrawals during the summer months for rice farming on the upper coastal plain near Houston. The waters of the Trinity River and its San Jacinto tributary serve as part of the water supply for the City of Houston, the nation's fifth largest city. The Trinity River and the San Antonio River (tributary to the Guadalupe River) receive municipal and industrial effluent respectively from the large Dallas-Fort Worth metroplex and the city of San Antonio, the nation's tenth largest city. During periods of low natural discharge these effluents make up most of the actual flow.

Figure 3.2-2 indicates the relative amounts of surface-water resources used for different types of demands within the various basins. Generally, a much higher percentage of total demand goes for irrigation in the more southerly basins. Toward the north, where the bulk of the highest quality lignite is found, manufacturing and municipal uses predominate. In the central portion, municipal and agricultural uses generally dominate the total demand. Mining uses very little of the total water supply.

TABLE 3.2-3

SUMMARY OF STREAMFLOW IN GULF COAST LIGNITE REGION

			Unregulated			
Most downstream fresh water gaging station on	Drainage Area (Σ) (mi^2)	Average Flow (Σ) (cfs)	Average Runoff (cfs/mi^2)	Average Annual Runoff (in)	Extremes Low (cfs)	Extremes High (cfs)
Calcasieu River	1,700	2,613	1.54	20.9	r	182,000
Sabine River	9,239	8,443	0.91	12.3	270	121,000
Neches/Village Creek	(8,811)	(7,082/4,843)	0.80	10.8	- -	- -
Trinity River	17,186	7,155/6,489	0.42	5.69	102	111,000
Brazos River	44,340	7,508	0.17	2.30	40	797,000
Colorado River	41,650	2,285r	0.55r	0.74r	0	84,100
Guadalupe/San Antonio	(9,119)	(2,219)	0.24	3.24	small	- -
Nueces River	15,600	858	0.55	0.74	0	141,000

Notes:

1. Figures in parentheses indicate summation of data on individual streams; "r" indicates significant regulation of flow; slash mark between figures indicates unregulated/regulated flow averages.
2. Mississippi River data through 1965, others through 1973.
3. Several very large springs discharge to Guadalupe River system.

Source: US-394 through 398; US-146 through 150.

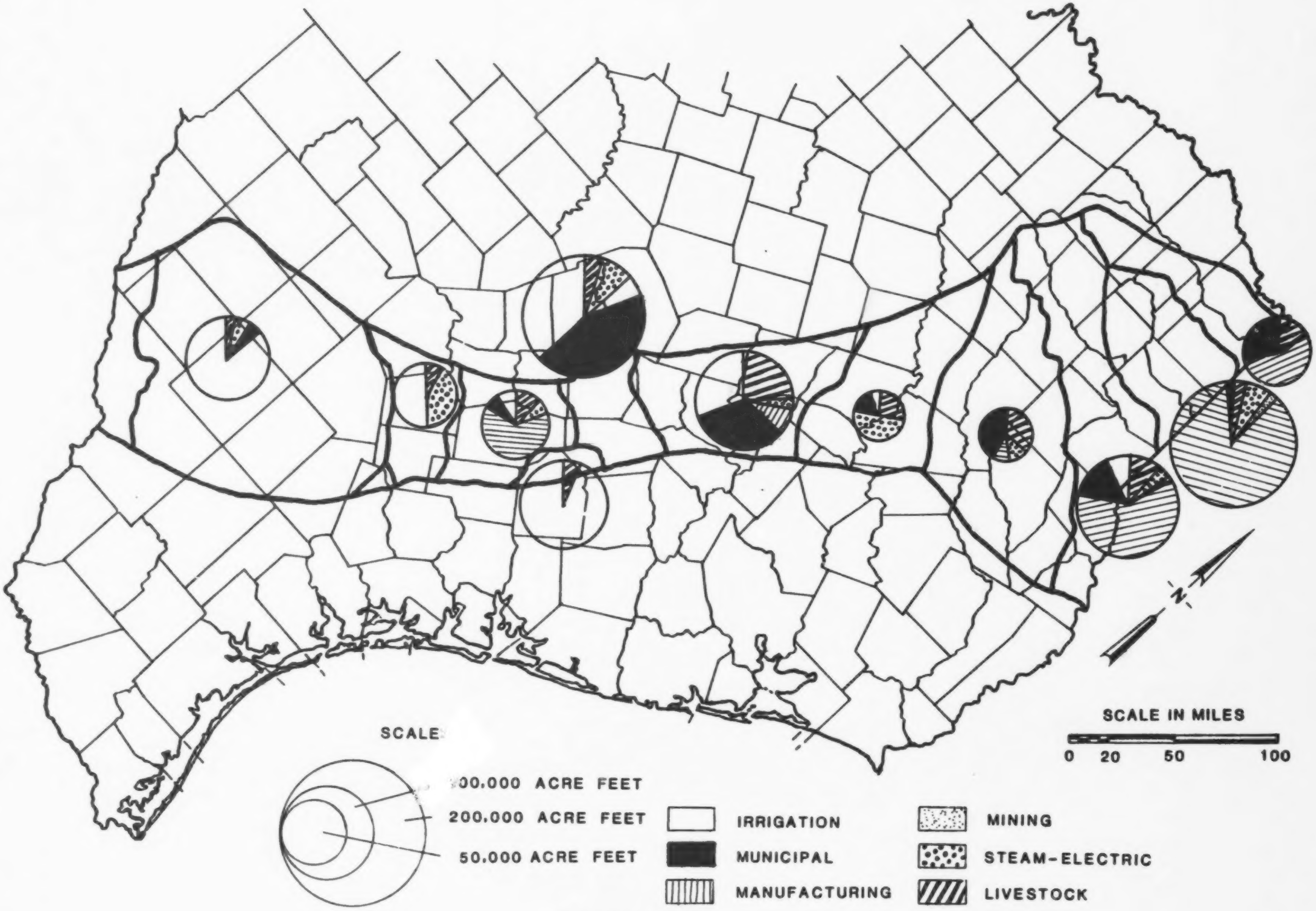

SCALE
00.000 ACRE FEET
200.000 ACRE FEET
50.000 ACRE FEET
IRRIGATION
MUNICIPAL
MANUFACTURING
MINING
STEAM-ELECTRIC
LIVESTOCK
SCALE IN MILES
0
20
50
100
N

FIGURE 3.2-2

1974 SURFACE WATER USE FOR DRAINAGE BASINS AND SUB-BASINS

Power generation uses large quantities in the Trinity and Guadalupe basins. In the Guadalups basin, most of this water is used to generate hydroelectric power. In the Trinity basin, however, the entire amount goes to cooling.

Freshwater instream flow needs must be considered in addition to these demands. This in-stream needs are just now being addressed explicitly by federal and state agencies. The minimal flow patterns needed to sustain aquatic life have been quantified for only a few streams, none of them in Texas. Nearly every major stream in the lignite belt has a substantial estuary and associated marshlands that support an economically significant fishing industry. A critical requirement for these streams is to maintain natural seasonal patterns of variation in the quality and quantity of inflow. This pattern is critical to the maintenance of existing estuarine conditions. These flow variations are responsible for the influx of nutrients and movement of sediments. Their seasonality is a key parameter of estuarine ecosystem structure. Regulatory agencies are now required to evaluate water withdrawals and reservoir regulation with respect to ecological effects on the estuaries. The data base for this evaluation, however, is only in the formative stages. The Texas Water Development Board (now part of the Texas Department of Water Resources) has been charged by the Texas Legislature to prepare a detailed report on estuarine freshwater inflow requirements by 1979. These studies, which include hydrological and ecological simulation modeling, are now in progress. The U.S. Fish and Wildlife Service is also funding similar studies on a more local scale, to predict the impact of specific water development projects.

In comparison to streams of the eastern United States and to even the main streams of the western United States, the numerous rivers that drain the Texas coastal plain are relatively small. This means that an incremental increase in demand, such as could result from lignite development, can have a large impact on flow patterns. It also means that rising overall demand potentially affects all the users in the basin.

The surface water resource is almost completely allocated, particularly on those streams southwest of the East Texas region. Continued growth in surface-water use therefore requires additional conservation measures and wider application of water re-use. Water re-use has already begun to expand in industry, under economic pressure. Especially for individual large users, recycling and re-use can produce significant economic benefits. Consequently, those basins where manufacturing is a dominant water use may be in a better position to adjust to lignite-related increases in water demand than other basins. Use patterns in the agricultural sector, especially in irrigation, are harder to shift than industrial ones, in part because of the large capital expenditures required for equipment. Individual farmers and ranchers may have more difficulty financing newer, water-saving technologies than industrial operations. Municipal demand is very difficult to curtail, largely because there are few opportunities to conserve enough water to have basinwide significance. Also, many individual household decisions are needed to produce a measurable demand reduction. Figure 3.2-2 therefore suggests that the greatest potential flexibility in water use patterns probably exists in the northern part of the lignite belt. Fortunately this coincides with the greatest expected development of the resource.

Ground Water

Most of the ground water in the lignite belt is found in sandy strata which act as aquifers. The most important of these aquifers are the relatively continuous Carrizo and Simsboro sands, which lie stratigraphically immediately above and below the Calvert Bluff Formation, in which the lignite is found. The Carrizo aquifer is a major regional freshwater source for municipal, industrial, and agricultural use, especially on and near its outcrop. Other dominantly sand formations occur in a coastward direction and are also widely used as minor aquifers. These sands are generally isolated stratigraphically, and no significant lignite occurs within their recharge areas. However, these minor aquifers (especially the Queen City and Sparta sands) are locally important sources of water near the Yegua lignite trend.

In addition to the Gulf Coast aquifers, the alluvial materials along the major rivers, especially the Brazos River and to a lesser extent the Trinity River, are also aquifers that are locally used for water supplies. These aquifers are relatively small, hydraulically unconfined to semi-confined sand and gravel deposits, but can be highly productive. Their recharge and discharge is controlled primarily by the stream water level.

The principal aquifers potentially affected by lignite mining are the Carrizo and Simsboro. Figure 3.2-3 shows their relationship to the lignite-bearing Calvert Bluff Formation. The aquifers actually consist of a complex, hydrologically interconnected system of sand bodies which function as a single water-bearing unit. The manner of water movement into and through these aquifers is essentially the same in both. The Calvert Bluff Formation which lies between them is a mixed mud and sand formation. Although generally less permeable than the two aquiferous sand strata, the Calvert Bluff can transmit water under pressure. Thus the two aquifers connected through the Calvert Bluff.

The Simsboro and Carrizo aquifers are recharged primarily by rainfall and streamflow infiltrating the sandy strata where they crop out at the surface. In these areas, water is found at quite shallow depths, as shown by the location of the water table

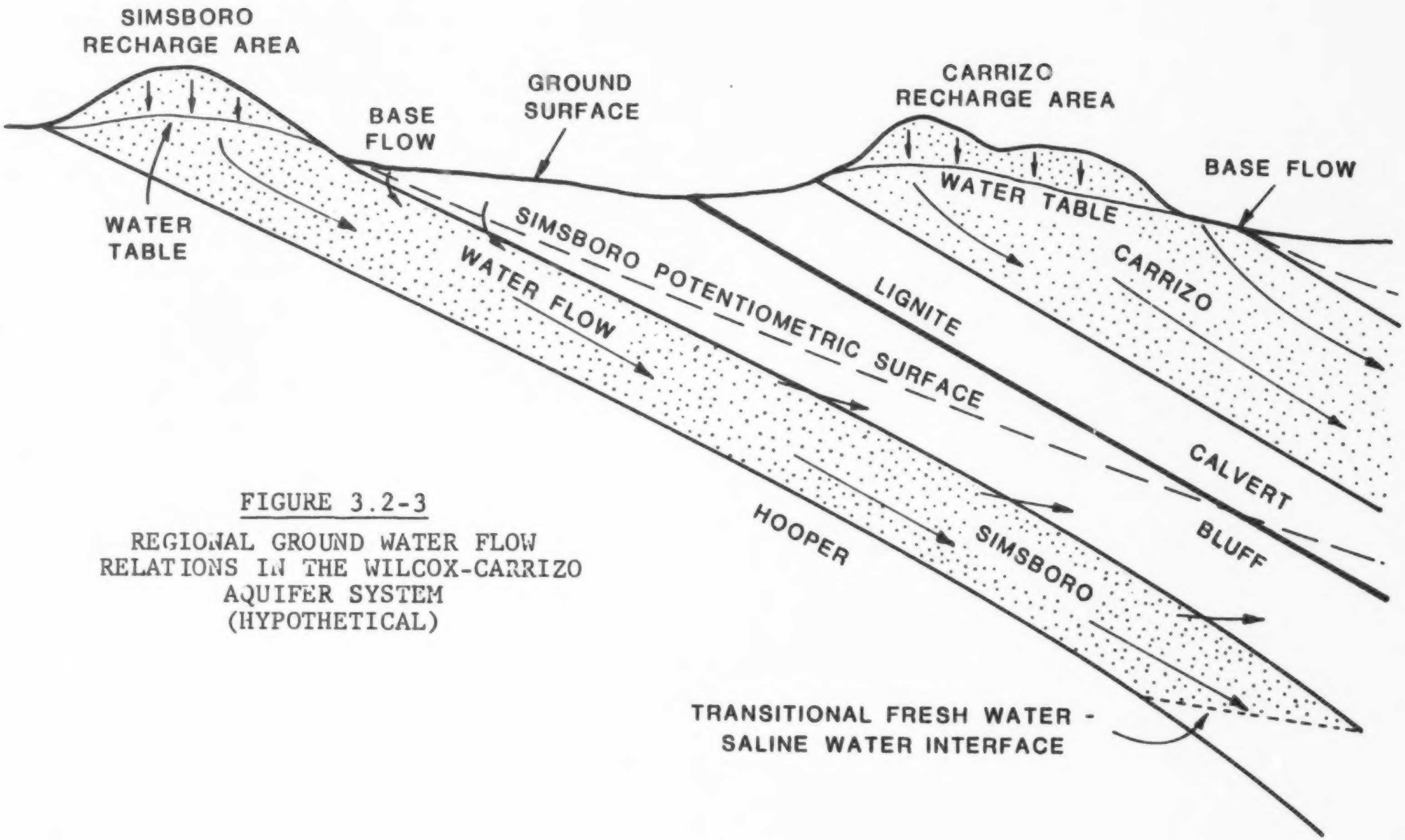

SIMSBORO
RECHARGE AREA
WATER
TABLE
BASE
FLOW
GROUND
SURFACE
CARRIZO
RECHARGE AREA
WATER TABLE
BASE FLOW
CARRIZO
LIGNITE
SIMSBORO POTENTIOMETRIC SURFACE
WATER FLOW
CALVERT
BLUFF
HOOPER
SIMSBORO
TRANSITIONAL FRESH WATER -
SALINE WATER INTERFACE

FIGURE 3.2-3

REGIONAL GROUND WATER FLOW RELATIONS IN THE WILCOX-CARRIZO AQUIFER SYSTEM (HYPOTHETICAL) in Figure 3.2-3. In a similar manner, a much smaller amount of water infiltrates the Calvert Bluff Formation.

Under the influence of gravity and subsequently under hydrostatic pressure, water moves very slowly downward, as shown in the figure. Because the water is confined in the sandy strata by the lower permeabilities of the adjacent strata, it develops substantial hydraulic pressure, or head. At sufficient depths, this pressure becomes strong enough to force water outward into the adjacent strata above. For water in the Simsboro aquifer, this is the Calvert Bluff. This outward movement is not uniform. It is restricted when locally adjacent to a very impermeable stratum (aquiclude). Elsewhere, faults may facilitate this movement by transposing strata of greater permeability or by providing an actual avenue for upward movement. Utimately, a small part of the recharge to the combined aquifer system is discharged into the Gulf of Mexico, perhaps hundreds of thousands of years later.

Ground water in the Carrizo and Simsboro sands is widely, though not intensively, used. Permeabilities and hydraulic conductivities vary considerably from place to place, affecting the productivity of wells. Typical sustained yields are on the order of 500 gpm.

The consumptive use of ground water from all of the aquifers in the lignite trend is shown in Figure 3.2-4, according to the various surface drainage sectors. Generally where surface supplies and usage are relatively large (Figure 3.2-2), groundwater use is small, and vice versa. Irrigation use is concentrated in the southwestern part of the trend, and virtually no ground water is now used for steam-electric power generation. With institutional and economic constraints on surface-water use increasing and with the availability of an underdeveloped groundwater resource, the relative proportion of the total water demand that is met by ground water is likely to continue to increase in this region.

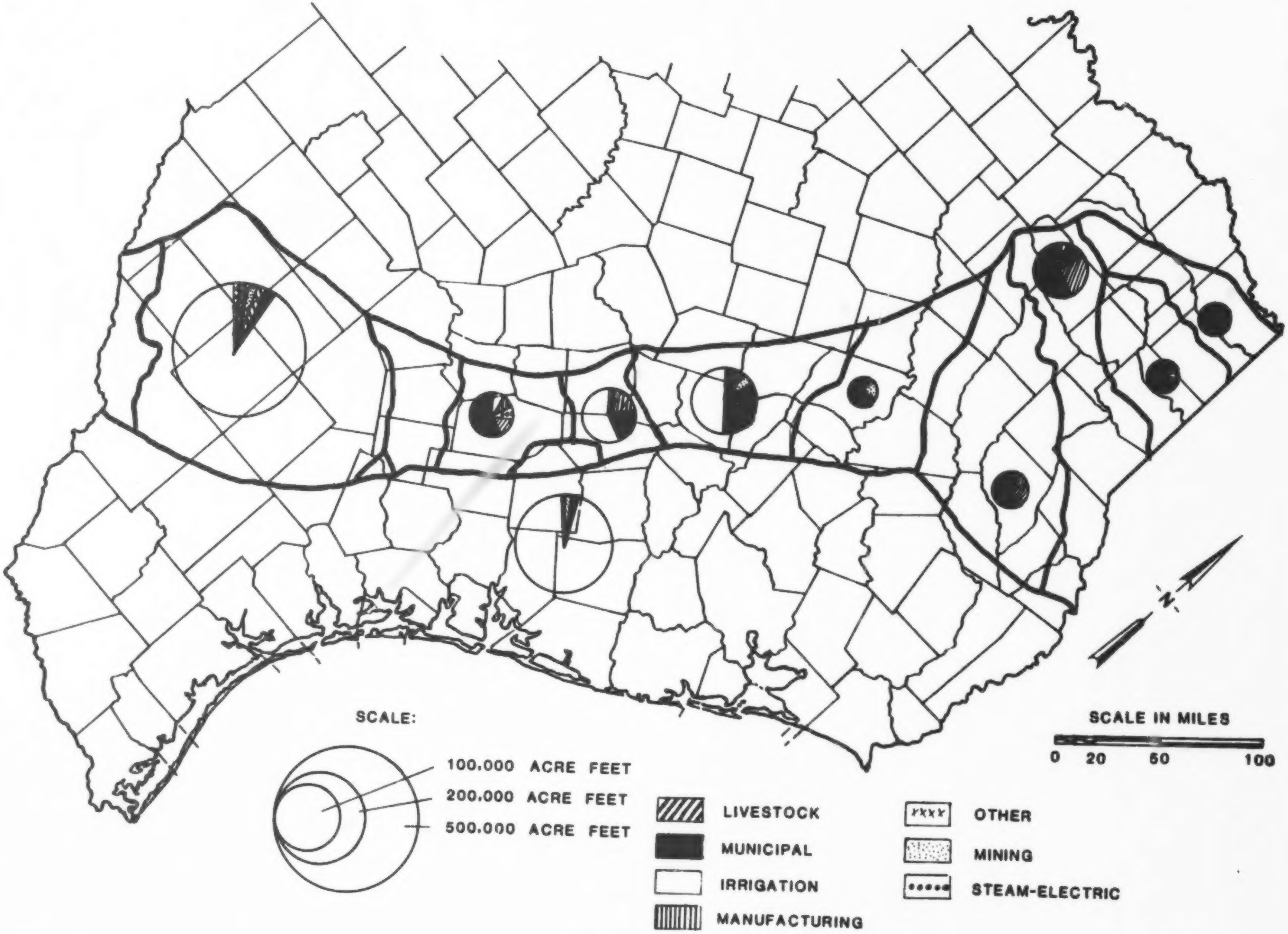

SCALE:
100,000 ACRE FEET
200,000 ACRE FEET
500,000 ACRE FEET
▨ LIVESTOCK
■ MUNICIPAL
☐ IRRIGATION
▥ MANUFACTURING
OTHER
MINING
STEAM-ELECTRIC
N
SCALE IN MILES
0
20
50
100

FIGURE 3.2-4

1974 GROUND WATER USE FOR DRAINAGE BASINS AND SUB-BASINS

3.2.3 Water Quality and Trends

Surface Water

The water quality of most streams is generally good during most of the year. There are no overriding geographic trends in natural water quality, except that streams in the southwestern part of the lignite belt tend to be higher in total dissolved solids (TDS) than in the northeastern part. On all streams, streamflow is the principal determinant of dissolved solids content. Typically, there is moderately strong inverse relationship between flow and TDS. An average TDS value may be 500 mg/ℓ.

Suspended solids generally vary directly with stream flow, and waters of the streams generally are turbid except just downstream of impoundments. Sediment yield from these watersheds averages about 1800 tons/square mile/year. Most of these streams usually carry a moderate load of organic material, largely of natural or non-point source origin. Although toxic organics are very low, persistent pesticides, presumably from agricultural land runoff, are accumulating to a small degree in bottom sediments.

Most streams that cross the coastal plain are deemed suitable for all uses, including public drinking water supplies. Pollution of surface streams by drainage from mined lands in the lignite belt has not been documented to date, and no (free) acidic mine drainage to surface streams is known to exist.

These streams exhibit a number of water quality problems however, both in the immediate vicinity of the lignite and farther downstream. These problems derive from both natural and man-made sources. Drainage from natural salt deposits in the upper Brazos River basin (far above the lignite belt) are a source of brine influent to that stream. This is the cause of its high dissolved solids load, especially during low flow conditions. Several tens of thousands of milligrams of dissolved solids per liter have been measured occasionally in the Brazos River and its tributaries. A similar problem occurs on some small tributaries of older streams, but does not substantially affect water quality in the lignite belt. Natural drainage from small basins containing lignite and its associated strata is also of impaired quality locally, but is rapidly diluted by waters of better quality in larger tributaries.

The water quality of all streams draining the region is affected by human activity to some extent. Mere consumptive use of the water has increased the in-stream salinity owing to loss of dilution. Return flows, particularly from irrigated agriculture, add salts directly. Below the lignite belt this has materially added to the dissolved solids loads. More important than this, however, is the widespread salt pollution from oil-field brines. Abandoned pits and poorly plugged or cased deep wells under artesian pressure have been of great local and even regional concern, although remedial and preventive measures have essentially reduced the current problem to local areas. Area-wide non-point source control is just now in the planning stages, under Section 208 of the Federal Water Pollution Control Act of 1972. These efforts will most likely focus on urban and agricultural land drainage as chief non-point sources.

Regulatory authorities are now placing most emphasis on point sources that may adversely affect water quality. Industrial and municipal (point source) discharges, abetted by hot weather and nearly stagnant flows, have created locally severe reductions in the dissolved oxygen content of some coastal streams. This has been particularly evident in the San Antonio River (a tributary to the Guadalupe River) and the Trinity River.

Some improvement in water quality has been effected in recent years by upgrading waste treatment facilities. However, the problems are likely to be difficult to solve completely, since the low flows of these natural streams are generally effluent-dominated.

Ground Water

The natural quality of ground water in the lignite belt ranges from fresh to briny, depending on a number of factors. Generally water near the outcrop of aquifers is fresh, but becomes more saline as it move gulfward. Consequently, at a given location water generally is progressively more saline with depth even within the same aquifer, although zones of especially high permeability may contain fresh water at considerable depths. In general, fresh water (containing less than 100 mg/ℓ dissolved solids) may be found in the Wilcox-Carrizo aquifer at depths as great as 5,000 feet. In the other Gulf Coast aquifers, ground water remains fresh to no more than about 2,000 feet (less in the southern part of the region) (TE-231).

Normal interformational leakage tends to degrade water quality. Salt domes may have a profound yet erratic adverse effect on the quality of nearby ground water. The area near a salt dome is usually fragmented into smaller reservoirs by faulting, each of which is variably affected by dissolution of salt. Upward discharge of brine from deeper strata can occur via these faults. Away from salt domes, the "background" water quality in the deeper aquifers ranges typically between 50,000 and 100,000 mg/ℓ of dissolved solids, primarily sodium chloride, with locally substantial amounts of dissolved hydrogen sulfide and methane (CO-373).

At shallow depths, water of the Wilcox-Carrizo aquifer system (comprising the Simsboro, Calvert Bluff, and Carrizo

Formations) is generally of considerably higher quality than other minor aquifers in the lignite belt. However, even within the Wilcox-Carrizo, extreme spatial variability in water quality exists, dependent upon stratigraphic location and the specific sediment types present. Generally, water in the Wilcox-Carrizo outcrop area is suitable for all uses. Water downdip (i.e., coastward) of the outcrop of the Wilcox-Carrizo aquifer, and ground water in the other minor aquifers progressively deteriorates in quality away from the outcrop. Dissolved solids, iron, sulfate, and chloride rapidly become only marginally acceptable in this direction, with respect to the secondary limitations of the National Interim Drinking Water Standards, and then with less stringent standards as well.

Man-induced changes in the quality of these aquifers are essentially negligible. Infiltration through lands under intensive agriculture and changes in quality as a result of altered flows caused by intensive ground-water development are the most important potential existing sources of ground-water pollutants. However, no documented cases of such pollution in the Wilcox are known to exist. These effects, if any, are now probably indistinguishable from natural variations, due to the lack of such intensive development.

3.2.4 Soils and Overburden

Soil associations are defined as groups of distinct soil series occurring together in predictable patterns and characteristic proportions. Commonly, two or three soil series comprise the map units in this system. Each soil series represents soils essentially uniform in kind, thickness, and sequence of horizons and very similar in their physical, chemical, and mineralogical characteristics.

Most active and proposed surface mining operations are within three soil-ecological regions of the state; namely: the South Texas Plains, the Post Oak Savannah-Blackland Prairie, and the East Texas Pineywoods.[1] Most of the upland soils in the South Texas area are dark, clayey soils. Bottomlands are brown to gray, silt loams to clay, and may contain some free lime.

Upland soils of the lignite belt in the Post Oak area are sandy loams, commonly thin, over gray, mottled or red, firm clayey subsoils. Deep sandy soils with less clayey subsoils also exist in some areas. Bottomlands in this region are reddish brown to dark gray, loamy or clayey alluvial soils. In general, soils in floodplain areas are deep, clayey, slowly permeable and calcareous. They are generally much more productive than the upland soils.

Most of the upland soils in the East Texas timberlands are light colored, acid sandy loams and sands, with some red soils. Bottomlands in this region may be light brown to dark gray, acid, sandy loams, clay loams, and clays. In general, they have loamy or sandy surface layers and reddish mottled loamy or clayey subsoils.

---

[1] See Figure 3.3-1

In their natural state, most of the soils are good grassland and woodland soils with moderate to low natural fertility in the A and upper B horizons. Depending upon the soil-formation process, some subsurface horizons may be more fertile than surface horizons.

The texture of overburden varies from sandy, sandy loams, silty loams, silty clay loams to silty clays. In general, lignite seams are separated by clay or sand and clay layers.

The overburden material, except that in Rio Grande and Brazos River areas, presents no potential salinity or alkalinity hazard.

The erosion potential of the mine spoil material ranges from low to extremely high levels. Although, during initial years, young mine soils strongly reflect the nature and characteristics of their parent material, they will not behave as normal agricultural soils. (They may be variable in water holding capacity, devoid of plant nutrients, contaminated with some salts and heavy metals, and subject to wind and water erosion. Under certain situations, high sulfide content and resulting low pH have been responsible for the lack of adequate plant growth.)

In spite of some of these undesirable agronomic characteristics, adequate handling will probably improve many of them. The segregation of overburden material offers the opportunity to bury the toxic, acid-, or salt-producing strata It is expected that replacing finer clay layers at the surface may improve the water-holding capacity of the upper horizons in some areas. In addition, breaking up and mixing the overburden will improve not only the nutrient retention capacity, but other physical and chemical properties as well. The absence of rock in the overburden layers will facilitate this improvement. However, readily available nitrogen, phosphorus, and convertible organic matter are expected to be low in most of these materials They will need to be supplied by fertilization and surface management.

3.3 Biotic Components

3.3.1 Introduction

Lignite deposits underlie large portions of three major vegetation areas (GO-190) of Texas (Figure 3.3-1). These are the Pineywoods (15 million acres), the Post Oak Savannah (8.5 million acres), and the South Texas Plains (20 million acres). Only a portion of the 43.5 million acres comprising these three vegetation areas contains mineable lignite. Less than one percent of this area is likely to be disturbed (see Section 4.6.1). Two other vegetation areas are either surrounded by lignite deposit areas or are located such that they will probably be affected by lignite-induced developments. These are the Blackland Prairies (11.5 million acres) and the Edwards Plateau (24 million acres). Only about one percent or less of these vegetation areas (primarily the eastern edges of each and a pocket of Blackland Prairie surrounded by Post Oak Savannah) may be affected.

The major biotic provinces (BL-118) encountered with respect to fauna in the same lignite area are the Austroriparian, Texas, Tamaulipan, and Balconia. Various ecosystem or habitat types can be delineated by the distribution of animals characteristic of these biotic provinces into the main vegetation types. Each of these major plant-animal associations of the lignite region is discussed in general terms in the following sections. Emphasis has been placed on the current condition and future trends of the natural environment in the region.

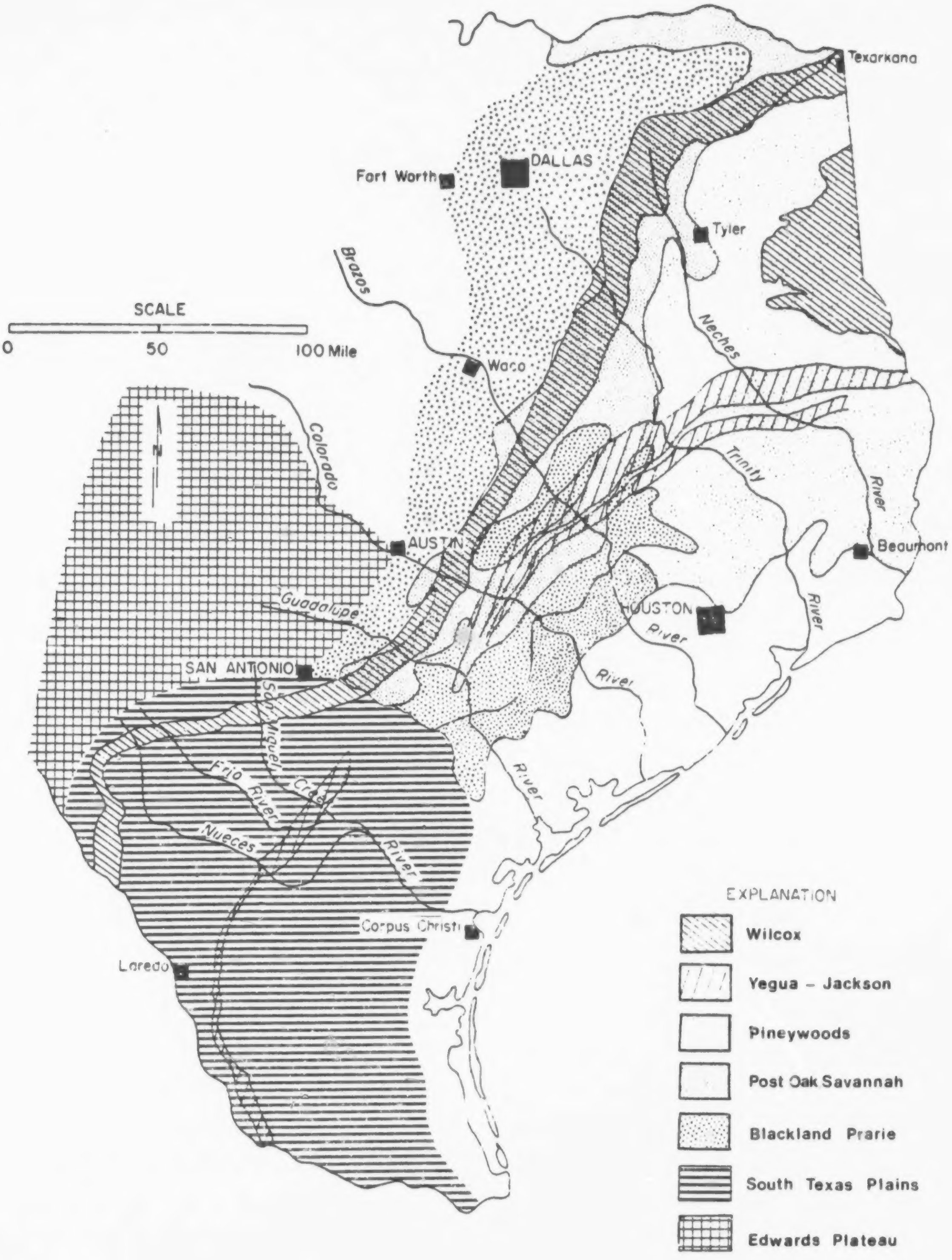

Texarkana
DALLAS
Fort Worth
Tyler
Brazos
SCALE
0
50
100 Mile
Waco
Neches
Colorado
N
Trinity
River
AUSTIN
Beaumont
Guadalupe
HOUSTON
River
River
SAN ANTONIO
San Miguel Creek
Frio River
Nueces
River
River
Corpus Christi
Laredo
EXPLANATION
Wilcox
Yegua - Jackson
Pineywoods
Post Oak Savannah
Blackland Prarie
South Texas Plains
Edwards Plateau

FIGURE 3.3-1

RELATIONSHIP OF STRIPPABLE LIGNITE IN THE WILCOX AND YEGUA-JACKSON UNITS (AFTER KA-152) AND MAJOR VEGETATION REGIONS OF TEXAS

3.3.2 Terrestrial Habitat/Vegetation Associations

Pineywoods

The Texas Pineywoods area marks the southwestern limits of the Oak-Hickory-Pine Forests (US-155) in the United States. This area has been logged for over 150 years and is still being used for both lumber and pulpwood for paper products. Virtually no virgin stands of timber remain in the upland pine forest area. Some of the riparian hardwood forests, although probably second growth, are approaching climax. The large amount of annual precipitation (44+ inches) aids greatly in rapidly restoring vegetation following disturbances. Some of this area has been cleared for agricultural purposes and livestock grazing. A large portion of the remaining forests are privately owned and managed primarily for wood production. Clear-cutting is commonly practiced in pure pine stands and uncommonly in mixed hardwood areas. The state's only national forests are located in this region.

Due to the continued large-scale disturbances of habitats from logging, farming and ranching operations as well as direct disturbance from heavy hunting pressure, the animal populations are much lower than they were prior to the coming of the white man. The species diversity is higher because of more varied habitats, however. This has drastically altered the original species composition.

The increasing need for wood products and agricultural products, along with an increase in recreational and retirement home subdivisions, point to increasing disturbances in the Pineywoods region. The riparian hardwood forests may be the last affected because of the higher degree of difficulty associated with development in the river floodplains.

Post Oak Savannah

The Post Oak Savannah region directly overlies the majority of the surface mineable lignite in Texas. This Post Oak-Blackjack Oak Savannah has been extensively cultivated and grazed since the first settlers arrived in Texas. This vegetation area is in the transition zone between the eastern United States forests and the central United States grasslands. Originally much of the area was prairie interspersed with hardwood forests in the drainage areas. Species of plants and animals from the western grasslands and eastern forests inhabit this transition zone wherever they can find a niche that suits their requirements. Disturbance by man (hunting, agriculture, overgrazing, and protection from fire) has increased the diversity of habitats, increased the extent of the oak woodlands and the mesquite savannah, and decreased the number of individual animals in this area. Many of the present oak forests are situated on cotton fields abandoned 75 to 100 years ago.

The Post Oak Savannah region will continue to be severely disturbed overall since the need for beef and agricultural products is increasing rapidly. Most of this area is in the 30 to 40 inch per year rainfall belt which means that evaporation more or less equals precipitation in much of the area, thereby making revegetation after disturbance occur more slowly.

Blackland Prairies

Originally this vegetation region was characterized by 1-2 meter high grasses that stretched as far as the eye could see. Presently only isolated, protected spots contain true prairie within the entire region. Agriculture and cattle grazing have taken over the vast majority of the Blackland Prairie area. Hardwood forests occur in the riparian areas where crops are not grown. Overgrazing has favored the growth of unpalatable grass species and mesquite in the pasturelands of the Blackland Prairie. Although no strippable lignite lies under the Blackland Prairies of Texas, the lignite belt surrounds a portion of this vegetation/habitat type and joins it on most of its eastern border.

South Texas Plains

The South Texas Plains region was originally a rocky to rolling prairie to savannah area with grasslands interspersed with brushy woodlands in the water courses. Hundreds of years of overgrazing, fire control and other poor management practices have left most of the 20 million acres in dense "brush" of one type or another. This provides good habitat for many species of dry country animals, especially since the density of the brush in many vast areas keeps disturbance by man to a bare minimum. This areas contains some of the largest trophy white tail deer in the United States--a valuable resource for property owners. Recent brush control efforts coupled with the re-establishment of native grasses and reasonable grazing practices have brought many of the less rugged areas back to more nearly natural conditions. Since this region receives less than 30 inches of rainfall annually, evaporation exceeds precipitation. This makes revegetation after disturbances a slow process without the addition of water.

Since the region is quite fertile when water is available and the brush removed, the trend is probably toward more clearing for pastures. This will proceed slowly and only as long as beef is in demand and water is available.

Edwards Plateau

In its original condition, the southern and eastern edges of the Edwards Plateau region, near the Balcones Fault, suported a prairie grassland on its upper more level hilltops.

Juniper-Oak thickets grew on the hillsides, and Oak-Walnut-Cedar Elm forests along the riparian areas. Overgrazing, depletion of underground aquifers that supplied the abundant springs, fire control and cutting of the various trees has greatly reduced the quality of the habitats available. Many areas are either sparsely vegetated rocky soil or dense stands of Juniper-Oak brush. These support one of the densest deer populations in the United States along with a good population of turkeys. The change in habitats has, however, caused declines in other populations such as the rare Golden-Cheeked Warbler.

The primary trend presently obvious is the urbanization of this scenic area by vacation, second home, and retirement communities. Although this does not place as much large-scale pressure on the habitats as clearing for agriculture might, it does greatly affect the wildlife directly through human disturbance and indirectly via changes in water quality, etc. The latter has the potential for affecting the several rare species of salamanders that inhabit the springs of the Edwards Plateau region.

3.3.3 Aquatic Ecology

The surface mineable and deep deposits of lignite in Texas cross almost every major river within the state. Texas rivers and estuaries contain thousands of species of aquatic plants and animals, each with its own set of tolerances and preferences for various water parameters. The species composition, species diversity, and population sizes vary between rivers and within each river depending upon a wide variety of environmental parameters. Since Texas has no natural lakes, all of the native fresh water organisms are riverine in nature, even though they may reside in man-made impoundments. Some species have been artifically introduced into the Texas river systems from various sources outside the state.

In general, the majority of the aquatic organisms found within the lignite region in Texas have rather broad tolerances of environmental parameters. Notable exceptions are species which inhabit springs or spring fed rivers near or in the Balcones Fault Zone along the southern and eastern edge of the Edwards Plateau. These are not in areas that will be directly affected by lignite development. Data are available for many species concerning their tolerances to various changes in water quality and quantity parameters. Since the effects of lignite development on aquatic ecosystems will be specific with regard to river systems, the aquatic biota of each specific area of lignite development must be studied separately.

In general, the extensive development of the land around the major rivers has altered water quality, quantity, and aquatic biota drastically. From the time of the early settlers in the 1800's through the early 1900's, the aquatic environments were grossly abused. They were used as dumping grounds for every imaginable waste material. In addition they received large loads of soil from poorly managed agricultural fields and over-grazed pastures. By the first part of the 20th century most of the fish had been removed from the rivers by over-fishing (commercial) or the degradation of their habitats. Efforts by the old Texas Game and Fish Commission (now the Texas Parks and Wildlife Department) have restored many of the depleted populations to reasonable levels. Still, pollution levels in the rivers and consumptive usage of the water resources strain most of the states aquatic resources.

The trend is toward increased water usage thereby increasing pressure on the aquatic ecosystems of Texas.

3.4 Sensitive or Unique Areas

Several areas have been described as "sensitive" or "unique" in the previous sections. This section summarizes these discussions and presents these areas in a combined form.

Sensitive or unique areas are areas which for certain reasons are thought to be sensitive to the effects of lignite development or unique in properties that should be considered in the discussions of lignite development. The sensitivity or uniqueness may be natural (wildlife habitats) or man-made (air quality maintenance areas).

State parks, national forests and grasslands, and wildlife refuges are considered sensitive to lignite development (see Figure 3.4-1). The flora and fauna of these areas are sensitive to disturbances of various types that would be aggravated by many areas of lignite related development. The Big Thicket area in East Texas is especially notable for its close resemblance to the natural climax forest as it existed before settlement.

The "Lost Pines" area near and including Bastrop State Park is a unique natural area because of the existence of the disjunct pine forest. This pine forest area is physically separated from the major East Texas Pineywoods by about 100 miles. This area contains other plants and animals usually found only in the Pineywoods region and is therefore unique in the lignite belt.

Areas of mature river bottom hardwoods along rivers or streams of Central and East Texas can be considered unique for their wildlife and scenic value. A segment of the Guadalupe River above Canyon Dam has been proposed for inclusion in the Wild and Scenic Rivers system. Since there are virtually no

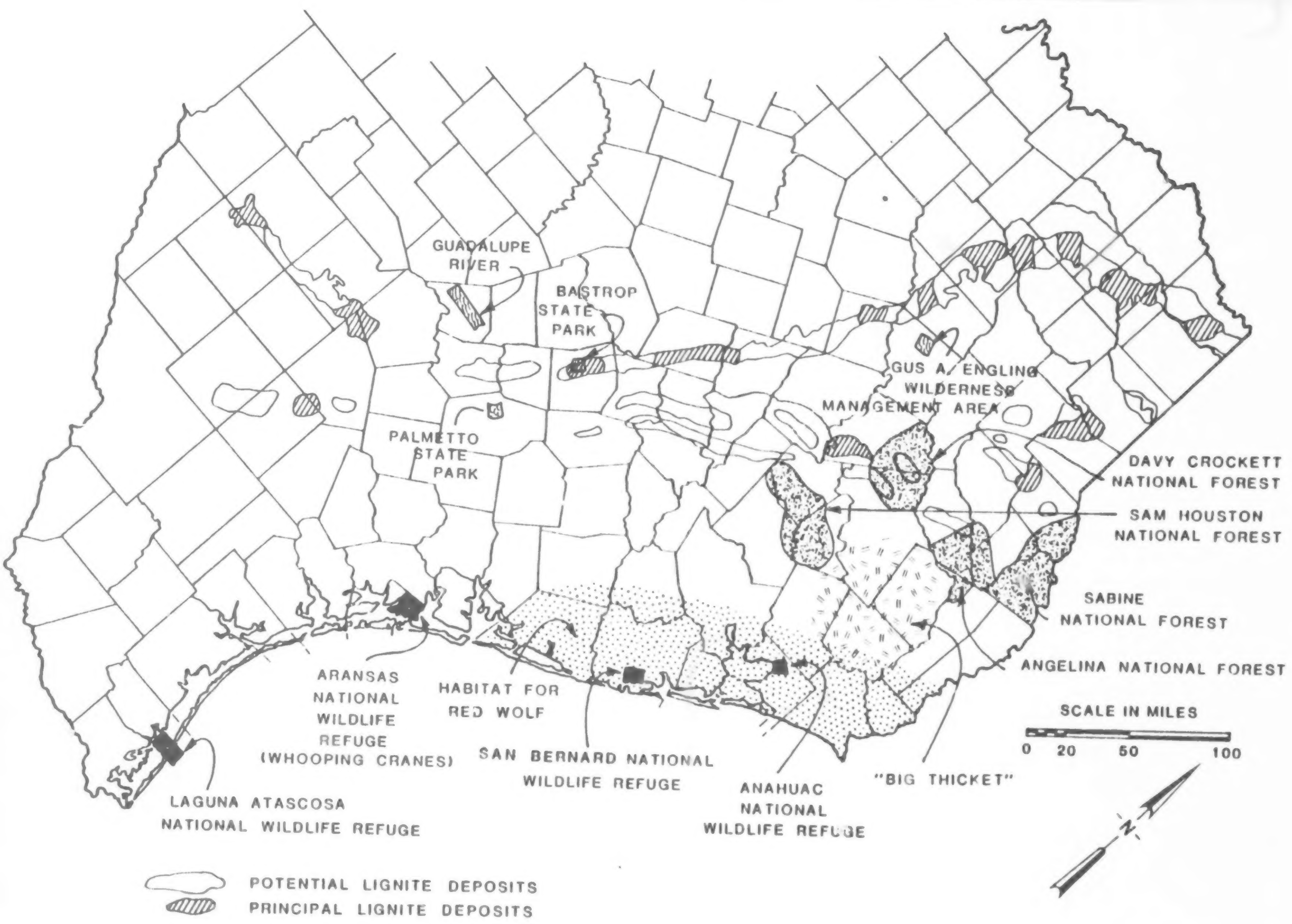

GUADALUPE RIVER
BASTROP STATE PARK
PALMETTO STATE PARK
GUS A. ENGLING WILDERNESS MANAGEMENT AREA
DAVY CROCKETT NATIONAL FOREST
SAM HOUSTON NATIONAL FOREST
SABINE NATIONAL FOREST
ANGELINA NATIONAL FOREST
SCALE IN MILES
0 20 50 100
N
"BIG THICKET"
ANAHUAC NATIONAL WILDLIFE REFUGE
SAN BERNARD NATIONAL WILDLIFE REFUGE
HABITAT FOR RED WOLF
ARANSAS NATIONAL WILDLIFE REFUGE (WHOOPING CRANES)
LAGUNA ATASCOSA NATIONAL WILDLIFE REFUGE
POTENTIAL LIGNITE DEPOSITS
PRINCIPAL LIGNITE DEPOSITS

FIGURE 3.4-1

ECOLOGICALLY SENSITIVE AREAS

virgin forest areas left in or near the lignite region due to previous logging operations, these areas of mature, near climax vegetation can be considered unique. Their replacement takes over 100 years under the best conditions; therefore, any disturbance should be considered long-term.

Air Quality Maintenance Areas (AQMA's) (Figure 3.4-2) are legally sensitive to further air quality degradation. Lignite mining and the related development of power generation facilities can possibly have an adverse effect on the levels of several criteria pollutants such as SO_2 and Total Suspended Particulates (TSP) if not carefully planned.

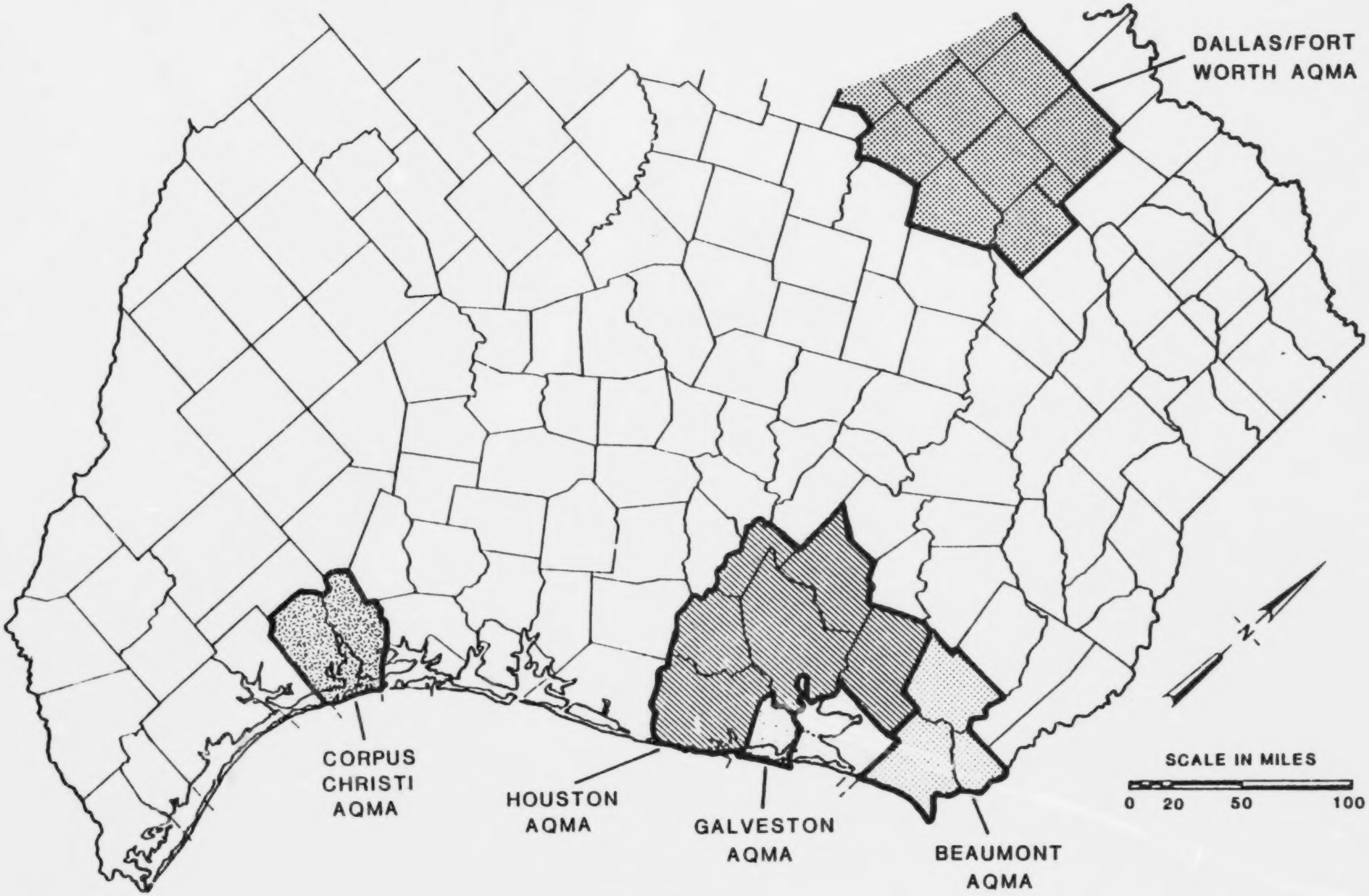

DALLAS/FORT WORTH AQMA
CORPUS CHRISTI AQMA
HOUSTON AQMA
GALVESTON AQMA
BEAUMONT AQMA
N
SCALE IN MILES
0
20
50
100

FIGURE 3.4-2
CURRENT AIR QUALITY MAINTENANCE AREAS

4.0 POTENTIAL ENVIRONMENTAL IMPACTS

4.1 Socioeconomic Consequences of Lignite Development

The following discussion will describe the major types of activity which can be related to future lignite development in Texas. This is a cursory analysis to be used for illustrative purposes rather than as a planning tool. Also, it will be used as input to other impact sections (e.g., water supply and air quality) so that the total potential impact of lignite development can be projected.

A number of simplifying assumptions have been made. The most important of these assumptions is that virtually all the lignite to be used in Texas between now and 2000 will be for electricity generation. The future demand for lignite for industrial process use, in-plant power generation, and gasification is too uncertain to forecast quantitatively without substantially greater efforts than were possible under the present study. However, industrial lignite use will probably fall in the same order of magnitude as use for power generation. This assumption consequently results in low estimates of impact. In this analysis, the direct economic impacts of lignite development have been isolated in two major economic sectors: lignite mining and electricity generation.

Excluded from this analysis is the manufacturing of machinery and the provision of materials for mining activities and electricity generation plants. This assumption is valid since much of the equipment (draglines, trucks, steel, etc.) will come from outside Texas, making the impact difficult to isolate geographically.

Preceding page blank

Finally, the economic stimulation related to construction activities will be excluded from this projection. As with materials and machinery, the consequences are difficult to allocate geographically because of "leakage" (spending outside a region). Also, the construction activities are of relatively short duration compared to the ongoing lignite mining and electricity generation.

In the sections which follow, the direct employment associated with various levels of lignite development will be estimated. Then, the indirect economic impacts associated with that development will be developed.

4.1.1 Direct Employment

To project future employment in lignite mining, it is first important to know how much lignite is going to be produced. Section 2.4 presented two projected rates of lignite development that roughly bound future use of lignite, depending on its attractiveness relative to other energy sources. The estimate of lignite development for power generation in 2000 ranges from a low of 128 MST (million short tons) per year to 257 MST per year.

To determine the number of workers who will be employed in the production of the lignite, it is assumed that current mining practices will be employed. A proposed Central Texas lignite mine which will produce 5 MST per year will employ 385 people, or 77 people per MST. A larger mine might employ fewer people per MST while a smaller mine might employ more per MST. However, for this cursory projection, 77 per MST is a reasonable estimate.

If lignite production grows to 128 MST in 2000, an increase of 120 MST over 1974 levels, approximately 10,000 new mining jobs will be created. Producing 257 MST per year in 2000 will create approximately 20,000 jobs. These are rough estimates, yet they show the relatively large number of jobs which can be created directly in lignite mining. The total employment in 1974 in all energy extraction (coal and lignite, crude petroleum and natural gas) for the entire area, was only 110,000 (TE-257). Thus lignite development can add significantly to employment in this sector.

The other sector which will be directly affected by lignite production will be electrical generation. The higher production figure corresponds to roughly 43,000 MWe in 2000, the lower to 21,000 MWe. As shown in Table 2.4-4, this is equivalent to 30 new 1,500 MWe stations at the upper bound, and 16 at the lower. Four plants are now in operation.

Utilizing contemporary staffing estimates, a 1500 MWe plant requires an operating staff of 500. Therefore, 26 new plants (four stations are now in operation) will increase employment in electrical generating by roughly 13,000, and 12 plants will increase it by 6,000.

Table 4.1-1 shows a summary of the direct effects of the three development scenarios on power production and on employment in the year 2000 in mining and power generation.

TABLE 4.1-1

SUMMARY OF EMPLOYMENT IMPACTS

Lignite Development	Mining Employment	New Power Plants[1]	New Power Generation Employees
257 MST	20,000	26	13,000
128 MST	10,000	12	6,000

---

[1] 1500 MWe per plant.

4.1.2 Indirect Employment

The economic effects of new activities such as mining and power generation do not stop with that new employment. There is a secondary effect on the economy. The Texas Input-Output Model (GR-355) shows how the various sectors of the Texas economy influence each other. A product of the model is a set of multipliers which quantitatively relate the change in economic activity which will result in all other sectors to growth (or decline) in a particular sector. Table 4.1-2 shows the forecast upper and lower bounds of lignite-fired power generation and the total employment growth which will result by the year 2000. Considering only the direct and secondary effects of lignite mining and power generation, there will be from 47,000 to 97,000 new jobs in the lignite region. This is actually an underestimate of the total effect because there may be changes in the economic structure of the region as a result of power availability. Also not considered have been the economic effects of plant construction. It should again be noted that these projections incorporate restrictive assumptions and cannot be used as planning figures.

TABLE 4.1.2
EMPLOYMENT FORECASTS

LIGNITE DEVELOPMENT SCENARIO	EMPLOYMENT IN LIGNITE MINING	MULTIPLIER	SECONDARY EMPLOYMENT	TOTAL DIRECT AND SECONDARY FROM MINING	EMPLOYMENT IN POWER GENERATION	MULTIPLIER	SECONDARY EMPLOYMENT	TOTAL DIRECT AND SECONDARY FROM GENERATION
257 MST	20,000	1.800	36,000	56,000	13,000	2.130	28,000	41,000
128 MST	10,000		18,000	28,000	6,000		13,000	19,000

GRAND TOTAL DIRECT AND SECONDARY EMPLOYMENT	
257 MST	97,000
128 MST	47,000

---

[1] Type II (indirect and induced effects) multiplier (GR-355).

4.1.3 Labor for Development and Population Change

The labor required for lignite mining and electricity generation is not currently available within the region. There is a fair amount of unemployed labor, in absolute numbers, near the lignite belt; however, many of these lack the skills needed for jobs in mining or power generation. A recent study in Milam County by Radian concluded that most of the new jobs will be filled by immigrants or commuters. However, secondary economic growth may be expected to generate more jobs for unskilled or semi-skilled labor.

No attempt will be made to project exactly the total population change which may occur along the lignite belt. However, if 3.0 people per household is a reasonable estimate of family size, there might be as many as 141,000 new people along the lignite belt in the 128-MST scenario and 291,000 new people in the 257-MST scenario. These projections are artifically high because they assume 100 percent in-migration. But even if these projections are reduced by 50 percent to allow for commuting and local labor availability, the region will still experience considerable growth. Since out-migration has been high during the past three decades, this change is potentially very significant.

The major conclusion of this analysis is that the lignite belt may experience a substantial population growth, for which it may not be prepared. Furthermore, these projections are conservative in that they ignore the growth of other industries, such as forest products, paper, and petrochemicals that may utilize the lignite. These industries will stimulate further economic activity and population growth. Since the Texas Input-Output multipliers are based upon existing patterns of energy use, they tend to underestimate this possibility.

4.1.4 Demands on Infrastructure

In Chapter Three, a number of features of the Texas lignite belt were discussed under the heading "Infrastructure and Recreational Resources". The discussion was brief and the major conclusion was that the non-metropolitan nature of the lignite belt may create problems which are not present in metropolitan areas. It also means that there may be some problems, commonplace in metropolitan development, which will not be bothersome in the nonmetropolitan case. The actual demands on infrastructure, therefore, will be site-specific and cannot be discussed in particular in this analysis. What follows is a general discussion of some aspects of the social infrastructure which may be affected by lignite development.

4.1.4.1 Housing

Lignite development in Texas will generally be restricted to areas where excess adequate housing is not now available. In a recent survey of a Central Texas town about to experience expanded lignite mining, Radian found that housing will be a critical problem in the early years of the development. In some of these areas with abrupt industrial expansion, large companies have had to subsidize housing developments. The problem is partially related to the lack of speculative development in nonmetropolitan areas when compared to metropolitan housing markets. Builders and financial institutions hesitate to act until there is demand which has little or no risk.

Inevitably, the shortage is dealt with by mobile home developments and long-distance commuting. Where zoning ordinances are favorable and the demand is sufficient, mobile home parks are a short-run solution to part of the problem. Those who do not find housing near a new activity must commute. This will be especially important in the lignite belt because the housing shortage, coupled with the demographic structure of the area, will insure that much of the labor will come from outside the region.

The positive aspect of the housing situation is that the solution means more jobs, particularly in the construction industry. Suppliers of building materials also benefit substantially. Financial institutions, savings and loans associations, in particular, profit from the shortage in the long run.

4.1.4.2 Education

Populations in those areas which will be immediately affected by lignite mining and power generation have relatively high median ages. This means that educational services in those areas currently are being provided to a relatively small number of pupils, especially when compared to suburban areas with relatively young populations. An influx of workers to most nonmetropolitan areas will upset the demographic structure. Workers will tend to be younger than the resident population and the number of children per household will be larger. This combination will probably mean that many educational systems will be overburdened. Radian found this to be true in an analysis recently conducted in a Central Texas town of 5000. Classroom space and the number of teachers will have to be expanded to meet minimum standards. In some areas, new schools may be needed. This was the case in a lignite-related development in Northeast Texas.

Stress on a school system is not necessarily a bad condition in the long run. Through increased revenues, an area may be able to renovate poor facilities or add to existing facilities to increase the quality of education. New ideas and teaching methods may be brought in by new teachers.

Finally, no one community will receive all the impact of a particular development. Past experience suggests that commuting may insure that the stress is dispersed to a number of schools and school districts.

4.1.4.3 Community Services

Municipal governments near lignite developments will experience varying degrees of difficulty in providing the expected services. The provision of basic utilities such as additional water and sewage treatment may be very difficult. Some communities will be forced to finance expansion through bonding. Communities that cannot provide additional services will not be able to attract their share of the economic activity.

One positive aspect of the development which may occur is reflected in the cost per capita of providing community services. The total cost is less in nonmetropolitan areas than in metropolitan areas. Table 4.1-3 shows the comparison of public expenditures in the two types of areas. Only in the per-capita cost of highways are the nonmetropolitan areas more expensive than the metropolitan areas. From a national perspective, nonmetropolitan growth may be desirable because of this type of savings.

TABLE 4.1-3*

PUBLIC EXPENDITURES

Service	Non-Metropolitan Cost ($/capita)	Metropolitan Cost ($/capita)
Police	6.56	16.73
Fire	3.46	9.77
Hospital	13.70	18.30
Schools	136.44	150.35
Sanitation	7.03	15.83
Welfare	11.88	24.17
Roads	26.77	21.14
TOTAL	205.89	256.29

*Based upon TW-008 (1966-67 data).

4.1.4.4 Conclusion

Non-metropolitan areas which attract large-scale developments will change substantially, especially in aspects discussed in this section. However, these changes are going to bring about other changes, particularly because of a natural dichotomy between "old timers" and "newcomers".

Newcomers may have more of the higher-paying jobs, which will cause some local inflation. Old timers, especially those on fixed incomes, will be hurt by this. Newcomers will have values which may be different from the old timers, especially since many of the newcomers will have recently experienced metropolitan ways of life. Old timers may perceive a change in political structure based upon these differing values. These are merely illustrative of some of the problems which may arise.

One moderating influence will be the high incidence of return migration which should accompany these developments. Many people who left nonmetropolitan areas in the 1950's and 1960's would like to return to their former homes if economic opportunity were available. Lignite development may be the stimulus for many of these people. The return of former residents might make the growth easier to accommodate.

4.2 Cumulative Effects of Water Demands

4.2.1 Demand Related to Lignite Development

Water consumption related to lignite development may be direct, such as that required for mineral extraction and power generation, or indirect, such as that associated with expanding residential, commercial, public, and other industrial end-use sectors as a result of lignite utilization. Both direct and indirect demands are related to the scale of lignite development, which has been described in Section 2.4.

4.2.1.1 Direct Water Demands

Direct water demands from lignite utilization arise from both mining and energy conversion, which in this analysis is limited to conventional lignite-fired steam electric power generation. Industry conversion to lignite as a fuel will not have as large an effect on water use as will the shift to lignite in power generation. Additional water demands may be a factor by 2000, but cannot be predicted. Pipeline slurry transportation is not technologically attractive, because lignite tends to disintegrate, when slurried, into a fine powder that is difficult to de-water (HO-389). Hence, cumulative water demands related to lignite development appear to be strongly dominated by electric power.

The principal water-consuming uses at a mine are dust control and reclamation. An average of 500 acre-feet per year (0.45 MGD) may be required for dust control for a typical 25,000 ton-per-day mine that supports a 1,500 MWe station. Generally, ground-water seepage that accumulates in the mine pit is of adequate quality for dust control, so this water use may make even a smaller demand on off-site water resources than 500 AF/year. Up to 4000 AF/year (3.6 MGD) may be required for reclamation, depending on natural rainfall in a given year and mine location. In East Texas and much of Central Texas, irrigation of reclaimed land is unnecessary. Further south, irrigation will probably be required for soil leaching and revegetation. A base amount of 500 AF/year has been allocated for reclamation at the typical mine under consideration. This is more representative of East Texas climatic conditions. Substantially more water for this purpose will be required if mines are to be located in southern Central and South Texas (say, south of the Colorado River.) However, the constraints upon extensive development there (water supply, lignite quality, and lignite quantity) militate against a larger estimate for statewide average reclamation use than 500 AF/year.

Water use in power generation is either for process or cooling purposes. The principal process water needs are for boiler makeup, ash handling (assuming hydraulic rather than pneumatic systems), and stack-gas scrubbing for sulfur oxide and particulate control. About 200 AF/year for boiler feed makeup and ash handling, and about 2000 AF/year for scrubbing are required for a 1,500 MWe station at full load. An additional 500 AF/year is allocated for miscellaneous in-plant uses.

Cooling water intake and consumption rates are highly dependent on the cooling system employed. Both cooling towers and cooling ponds consume from 30 to 100 percent more water than "once-through" cooling systems. Averaged statewide, about 10,000 AF/year would be consumed by a 1,500 MWe plant for once-through cooling. About 20,000 AF/year would be required for cooling ponds or towers. Once-through cooling is impractical in most of the streams in the lignite belt because of irregular flows. These flows are too variable to supply the volume of cooling water needed to keep discharge temperatures low enough to meet state stream quality standards. From a water-use efficiency standpoint, the use of once-through cooling on large multi-purpose reservoirs is optimal (HO-389), but few of these exist along the lignite belt. Their use for cooling is also hindered by requirements to comply with Federal law (see Section 5.1.2). Ground water is more efficiently used in wet cooling towers than as makeup for a cooling pond or lake.

No distinction has been made in this analysis between water use in cooling ponds and cooling towers. Unless viewed from an economic and historical perspective, this assumption may be misleading. There are, of course, differences in water requirements between these two systems at any one location. For example, cooling ponds tend to be more practical in East Texas than South Texas; in South Texas, the very high evaporation rates and low rainfall would increase water use significantly. Cooling ponds would tend to use about 20 percent more water than cooling towers. On the other hand, in East Texas, cooling towers may consume nearly 20 percent more water than ponds (TE-301). In Central Texas, the two systems are about equal in consumptive water use. A consumption rate of 20,000 AF/year is about the most efficient level achievable, and economics dictate consuming as little water as possible. The 20,000 AF/year rate for a typical 1,500 MWe station is consequently believed to be a good average figure, but it must be borne in mind that in East Texas it connotes the use of cooling ponds and in South Texas, use of cooling towers. In both of these systems, water intake will be virtually equivalent to water consumption.

Aggregated direct demands of lignite utilization in the year 2000 are presented in Table 4.2-1. For each mine, 1000 AF (0.89 MGD) is consumed annually, and its associated power plant will use about 22,700 AF per year (20.3 MGD). The water use figures in Table 4.2-1 are based on an upper bound of 30 mine-mouth power plants in the year 2000 and a lower bound of 16, as projected in Chapter Two, with an average load of 60 percent (the current load factor for all lignite-fired stations.) Most of this demand will occur in or near East Texas where surface-water supplies are more plentiful than elsewhere, and where additional water requirements for mine reclamation are negligibly small. On a Btu-output unit basis, water consumption will slightly increase in a southwesterly direction along the lignite belt and the proportion of ground water is also likely to increase. However, on a gallon-consumed basis, the water used for lignite utilization will progressively decrease in a southwesterly direction.

TABLE 4.2-1

PROJECTED WATER REQUIREMENTS DIRECTLY RELATED TO LIGNITE UTILIZATION IN YEAR 2000

	Lower Bound		Upper Bound	
	(AF/Yr)	(MGD)	(AF/Yr)	(MGD)
Mining	9,600	8.6	18,000	16
Power Generation	218,000	195	409,000	365
TOTAL DIRECT DEMAND	228,000	204	427,000	381

4.2.1.2 Indirect Demands

Indirect water usage related to lignite development derives chiefly from the increased population generated by the utilization of lignite. As shown in Section 4.1, in the year 2000, between 47,000 and 97,000 new jobs will be created by lignite mining and related power production. The maximum resulting population increase could be as much as 141,000 to 291,000 people,[1] all of whom will require water, among many other services.

Gross water use by this population increment will range from 19,000 AF per year (17.1 MGD) to 39,300 AF per year (35.4 MGD), based on 120 gallons per capita-day for domestic, commercial, and public uses in the lignite belt. Generally, these amounts of water are not all consumed, since about 83 percent on average is returned or introduced to the surface or shallow subsurface water supply system as wastewater, where it ultimately will be reused (not necessarily by humans). However, the gross water use figures *per se* are important, because generally this water is required to be of higher quality than water directly related to lignite utilization. Furthermore this water demand, while dispersed throughout the lignite belt, will be locally concentrated in the more urban areas, especially those of East Texas.

---

[1] Assuming 100 percent in-migration.

Net water usage (i.e., consumption) by the increased population must be used in assessing the overall effect on the hydrologic balance. These indirect effects are quite small; even in the year 2000, a maximum of only 6,680 acre-feet per year (6.0 MGD) can be ascribed to consumptive use by the increased population. This is essentially negligible when compared to amounts directly related to lignite utilization.

Another indirect water use is that for new industries whose existence is dependent upon lignite extraction and utilization. This water use has not been determined, but it may be a significant additional water demand related to lignite development. Generally, these demands are not necessarily co-located with direct and other indirect demands.

4.2.2 Water Availability for Lignite Development

By the year 2000, as much as 260 million tons of lignite may be mined annually and burned as fuel in the large steam-electric stations. The discussion in the preceding subsection indicates that consumptive water requirements may exceed 430,000 acre-feet per year at such utilization rates. There seems to be no question that such large continuous demands will strain available water supplies at least locally, if not basin-wide. Demands of large amounts of surface or ground waters for lignite utilization may not only compete with demands by other users from the same river basins or aquifers, but also may combine with other uses to reduce vital inflows to economically important coastal estuaries (see Sections 4.6 and 5.1 for further discussion). A detailed assessment of water supplies and availabilty, basin by basin or by aquifer, is not within the scope of this study (and may not now be possible.) The effects of the increased water demand therefore have been addressed only at a regional overview level. Emphasis of this subsection is on physical availability. The effects of institutional constraints on water use are the focus of Section 5.1.

Water requirements can be met from both surface- and ground-water resources, although the extent to which either resource can satisfy the demand is highly site-specific. Surface-water availability in the area of the lignite belt depends on the climate and resultant hydrologic conditions (see Figure 4.2-1). The availability of water in the lignite belt is discussed according to these climatic regions.

Generally speaking, some supplies of surface water are available in varying amounts above present usage in Central and especially East Texas. In these areas, relatively high average rainfall in the basins above the lignite and low evapotranspiration promotes high unit runoff. Nevertheless, in most areas of the lignite belt, surface streams are small and streamflow is largely dependent upon localized rainfall. In the immediate vicinity of the lignite, then, off-stream impoundments, supplied by water pumped from larger watercourses, must be used to provide a dependable water supply. In most of Central Texas and on some streams of East Texas, even the present water use exceeds dependable supplies, and make-up for the off-stream impoundments will increasingly make selective use of flood flows, as lignite development proceeds. Very little, if any, dependable water is not committed to existing water rights permits; the ongoing adjudication effort by the Texas Water Rights Commission (now in-

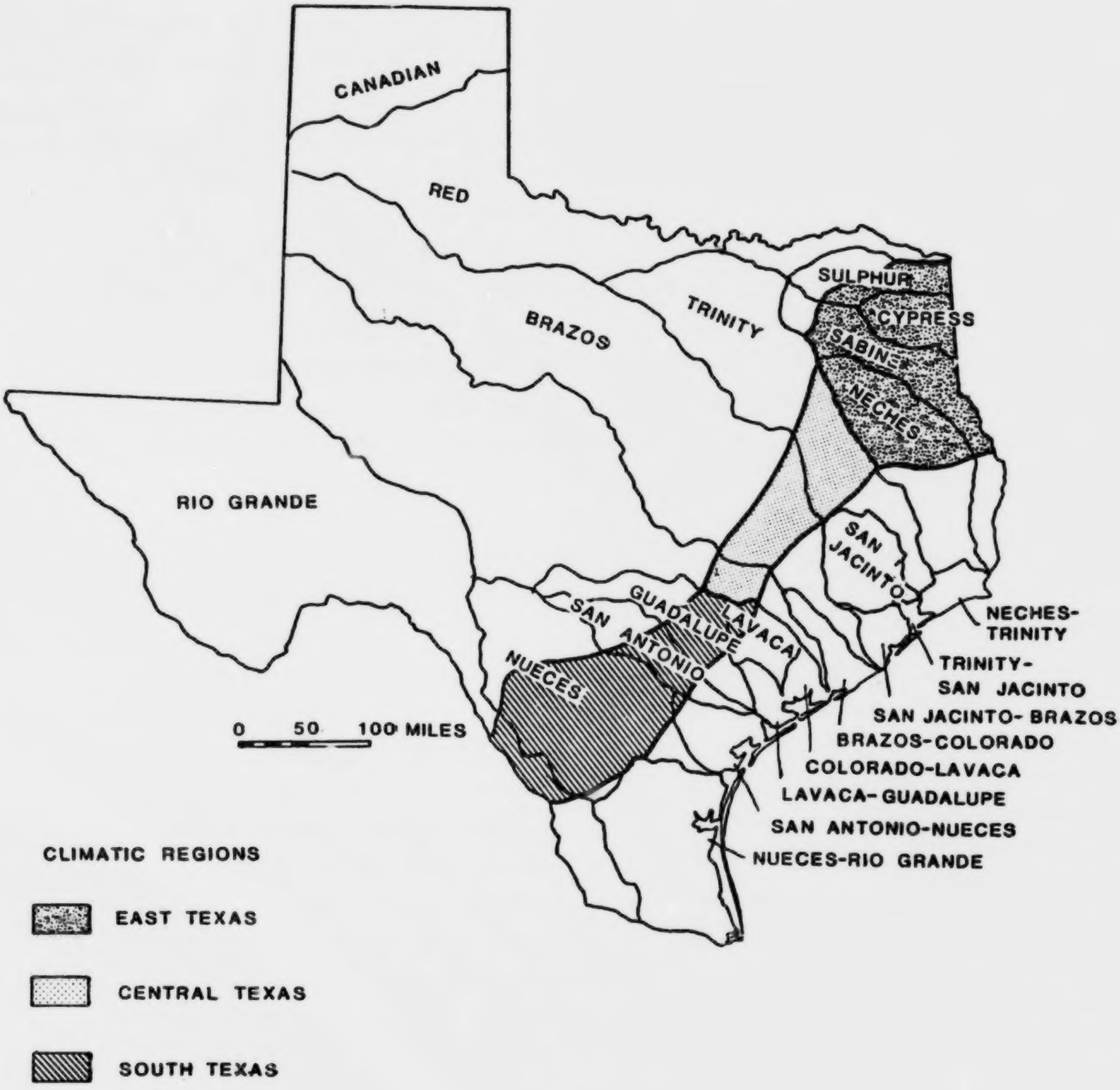

CANADIAN
RED
BRAZOS
TRINITY
SULPHUR
CYPRESS
SABINE
NECHES
RIO GRANDE
SAN JACINTO
GUADALUPE
LAVACA
SAN ANTONIO
NUECES
NECHES-TRINITY
TRINITY-SAN JACINTO
SAN JACINTO-BRAZOS
BRAZOS-COLORADO
COLORADO-LAVACA
LAVACA-GUADALUPE
SAN ANTONIO-NUECES
NUECES-RIO GRANDE
0 50 100 MILES
CLIMATIC REGIONS
EAST TEXAS
CENTRAL TEXAS
SOUTH TEXAS

FIGURE 4.2-1

CLIMATIC REGIONS IN THE LIGNITE BEARING AREAS OF TEXAS corporated in the new Texas Department of Water Resources) should reveal to what extent additional supplies for all uses are available for allocation. However, as a general statement, lignite development will strongly exacerbate an existing trend toward depletion of the surface-water resource in Central and East Texas.

In South Texas, surface water is not readily available. Its availability is generally dictated by economics, because any substantial amounts of water must be acquired from existing permit holders on a contractual basis (HO-389). Even such "contract water" will contain restrictions as to withdrawal periods and rates.

Total water usage projections, according to the Texas Water Development Board (TWDB) indicate that lignite-related water use will be a substantial portion of the total surface-water demand, and will significantly exceed the dependable supply. Table 4.2-2 compares total demand to low and average flow in the affected basins. Dependable supply is related to low flow, and lies between the two statistics, but closer to the low flow of record. (While lignite-related usage is a component of the total demand in these TWDB projections, the analyses of this study indicate that the lignite-related demand in the more northern basins will be more severe than that projected by the TWDB, and the demand on more southern basins less severe.)

Ground-water availability must be evaluated on a site-specific basis. Generally, though, ground water of suitable quality is more available in a southwesterly direction. This water resource is generally undeveloped and the sustained yield of ground water from the Carrizo Wilcox, Queen City, and Sparta aquifers is likely to be a more important water source in the future, especially for domestic and agricultural demands in

TABLE 4.2-2

MAJOR RIVER BASIN FLOW STATISTICS AND SURFACE-WATER USE*

(1000's Acre-Feet/Year)

Drainage Basin	Streamflow-Period of Record		Total Water Use	
	Low Flow	Average Flow	1974	2000
Sulphur River	0	1,101	50.8	97.5
Cypress Creek	0	250	171.3	122.5
Sabine River	195	6,102	105.4	310.8
Neches River	46	4,570	170.2	371.8
Trinity River	74	5,184	616.8	1516.7
Brazos River	29	6,055	504.9	1412.1
Colorado River	93	1,774	315.8	643.1
Guadalupe River	10	1,240	48.6	125.6
San Antonio River	1	448	40.7	175.1
Nueces River	5	629	75.8	88.5
TOTAL			2100.3	4869.7

*Streamflows are values at furthest downstream gaging stations

NOTE: Streamflows based on U.S.G.S. data (US-676)
Water use based on (TE-301)

the southern portion of the lignite trend. However, the massive ground-water supplies in extreme South Texas (in the "Winter Garden" area) are already now being mined because irrigators are withdrawing water from the prolific Carrizo-Wilcox aquifer at a rate exceeding recharge over wide areas. A continuation and areal expansion of ground-water mining is a probable consequence of lignite development in South and southern Central Texas. It appears likely that more intensive use of the surface-water resource, even in East Texas, as a direct result of lignite development will cause increasing reliance on ground water as a source of municipal and domestic water supplies. (These supplies must be of high quality and are therefore more limited). This increasing reliance is not necessarily unfavorable, but may lead to increased water production, transmission, and possibly treatment costs to be borne ultimately by the consumer. Also, local conflicts between agricultural use and use related to lignite utilization are also conceivable, especially in South Texas. Ground-water depletion incidental to mining may be of local importance, but generally should not be of regional concern.

A more comprehensive evaluation of impacts of future lignite utilization on water resources requires further study of specific water requirements as to quantity and quality for direct and indirect use, disaggregated according to source and basin, and a more specific basin and aquifer analysis in the immediate vicinity of mine sites. This is not possible in the present study.

4.3 Cumulative Effects on Water Quality

Lignite development will not only impose larger demands for rather high-quality water, but also may stress existing quality of surface and ground waters. The assessment of these potential effects is hampered by the lack of documentation of mine-related water quality impacts to date. Generally, however, direct water quality effects of lignite development may accrue as a result of either introduction of pollutants from mining and power generation, or indirectly by consuming assimilative capacities or altering flow regimes. Secondary effects are related to municipal wastewater discharges and domestic uses.

In general, while water quality effects must continue to be addressed at a site-specific level to avoid potential local problems, it appears that the long-term deterioration of water quality as a result of mining may be of concern only if a number of mines are closely associated and are discharging to the same surface and/or subsurface hydrologic system.

4.3.1 Water Pollutant Sources and Pathways

Both mining and lignite-fired power generation have a potential to degrade surface and ground water directly by introducing a variety of pollutants into the environment. Most of these sources and pathways are similar to those well-known ones discussed in numerous recent references (e.g., NA-172, DO-108, DO-143, WA-185) and such generic descriptions of impacts will not be repeated here. Rather, the focus of this discussion will be on specific features and characteristics of the Texas lignite belt and lignite utilization that may affect the extent to which significant impacts occur.

4.3.1.1 Mining Impacts

Suspended solids will probably be of most concern for surface water quality degradation as a result of mining. Overburden composed of the Calvert Bluff formation tends to have moderately high intrinsic erodibility, and spoil will usually require an extensive sedimentation pond system for adequate interim sediment control. Effluent limitations of PL 92-500 (Federal Water Pollution Control Act Amendments of 1972) and the new Surface Mining Reclamation and Control Act (PL 95-87) should provide assurance that the generally good experience with effective siltation control at existing mine sites will continue.

Perhaps of more concern is nonpoint-source stream siltation that results from hydrographic modifications, especially straightening and channelizing streams on the periphery of mined areas. Unless carefully planned and executed, these modifications can cause large increases in suspended sediment and bed loads due to bank instability and increased velocities (EN-102).

At most locations, seepage into the pit will be relatively minor, even though the water table is above the lignite to be mined. Perhaps 1000 gpm is an average or typical order-of-magnitude value for such seepage. This low discharge is due to the overall low permeability of the Calvert Bluff formation and Yegua-Jackson strata. At some locations, however, mining will intersect fairly extensive sandy zones which transmit considerable quantities of water downdip. These sandy zones, which usually correspond to fluvial and deltaic distributary channels associated with major depositional systems, occur locally throughout the lignite belt, and may necessitate the use of dewatering systems for seepage control. (Also, surface mining in a few areas of the lignite belt may intersect the very permeable alluvium of major modern streams, and similarly require seepage control.) Generally, such dewatering systems will involve discharge of significant amounts of ground water to rather small surface streams. Discharged shallow ground water in general will be more highly mineralized than average surface waters, with increased concentrations of major cations and anions, especially chlorides, sulfates, calcium, and usually iron. This quality, however, may not be very different than the water chemistry of low flows. To minimize surface quality degradation and and water impacts, dewatering products may be used for dust control, for reclamation, if of suitable quality, and even for electric power generation, if properly planned in the plant water management system.

No induced acidic mine drainage has been noted in either surface or subsurface waters in the vicinity of existing mines. This may be more a function of low substrate permeability, high-quality lignite and good mining techniques than the regional absence of acid-forming or toxic material. Certainly in areas where lignite has higher sulfur contents, (viz, South Texas and especially the Yegua-Jackson deposits), possible problems with acidic mine waters cannot be ruled out. Limited observations indicate some natural streams draining lignite outcrops have rather high iron and sulfate contents, and also (though rarely) have yellowish-orange stains along their banks. Some observed mine seepage that has been in prolonged contact with disturbed overburden exceeds secondary drinking water standards for chloride and especially sulfate, and conceivably some primary inorganic standards, although no data on the latter possibility are available. However, much Wilcox lignite in East Texas is rather low in sulfur (less than 1%); and, moreover, much of the sulfur is organically bound rather than in acid-producing pyritic form. This suggests that any noticeable problems with acidic drainage may not occur for some time, until the lower-quality lignite in the humid East Texas area is mined. It should also be noted that even though Wilcox lignite of South Texas has decidedly more acid-producing potential, the aridity of that environment may not generally promote formation of acidic drainage, especially in view of the limited development projected there.

The production of toxic concentrations of heavy metals or other substances as a result of mining also has not been documented in the lignite belt. Some infiltration undoubtedly will encouter zones in the disturbed overburden that are of inferior quality, and may be degraded, but such strata apparently are not widespread, either areally or stratigraphically. However, such infiltration is difficult to detect and some degraded recharge from existing mined areas may be entering the regional ground water system of the Wilcox aquifer. Such flow is hydraulically possible, where the lignite is hydrologically connected with the recharge area of a major aquifer zone (see Figure 4.3-1). However, the vertical leakage of degraded water through the Calvert Bluff aquitard to the Simsboro or its equivalent is likely to be small in relation to the mass flux through the aquifer, so water quality problems due to any undispersed pollutants are likely to be of only local, if any, significance. Aquifers associated with the Yegua-Jackson lignites tend to be very restricted and so mineralized naturally as to be unsuitable for most water supplies; effects of toxic materials entering these small, discontinuous sands are likely to be inconsequential. Again, it is reiterated that nowhere in the lignite belt have these hypothetical situations been realized at present.

4.3.1.2 Impacts of Power Generation

Operation of lignite-fired power plants may produce both aqueous and solid waste streams that may degrade water quality. Generally though, application of effluent limitations in PL 92-500 (the Federal Water Pollution Control Act Amendments of 1972) are sufficient to protect surface water quality. Furthermore, for many locations in the lignite belt where off-stream impoundments are possible, zero-discharge to surface waters may be obtained under proper water management, except during extremely heavy, prolonged rainfall events.

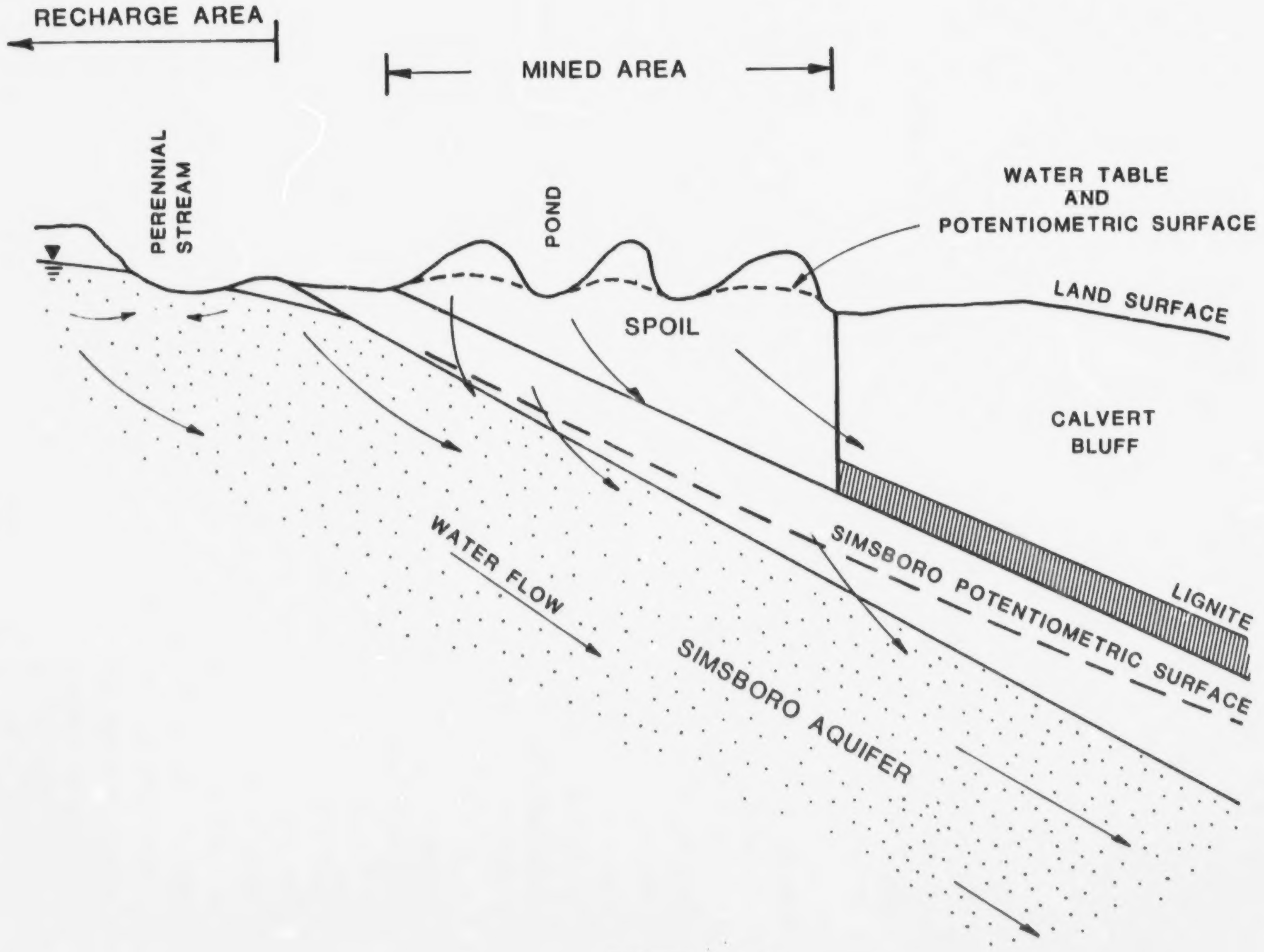

RECHARGE AREA
MINED AREA
PERENNIAL STREAM
POND
WATER TABLE AND POTENTIOMETRIC SURFACE
LAND SURFACE
SPOIL
CALVERT BLUFF
LIGNITE
SIMSBORO POTENTIOMETRIC SURFACE
WATER FLOW
SIMSBORO AQUIFER

FIGURE 4.3-1

LOCAL GROUND-WATER FLOW RELATIONS AFTER MINING IN CARRIZO-WILCOX AQUIFER (HYPOTHETICAL)

However, discharges to ground water are usually not avoided or directly controlled. Leakage from ash and scrubber sludge ponds and also cooling reservoirs eventually will enter the regional ground water system or will be discharged to surface streams after residing in the subsurface for some time. Generally, lignite will generate more ash and scrubber sludge than imported coal, and lignite's utilization may therefore require more surface area dedicated to control of ash and sludge. Most of these ponds will be located in East and northern Central Texas, where ground water use is likely to increase dramatically by the year 2000.

The ponds will be sites of relatively concentrated recharge, which may contain considerably higher major and minor constituents than the shallow ground water. In particular, ash ponds have relatively high pH's and may contain elevated concentrations of soluble trace elements as well as major cations and anions. Cooling reservoirs, on the other hand, even if located directly on the recharge zone, will generally contain water of high quality and are not deleterious; their effect is more hydrodynamic than water quality-related.

Ash and scrubber sludge ponds are usually integrated into a water management system. In such systems, all aqueous (and volumetrically most solid) wastes are at least temporarily stored in ponds, where the supernatant is discharged as overflow to surface streams or as leakage to the subsurface. Any containment pond which discharges to a surface stream without further treatment is subject to regulation, which thus indirectly controls the quality of seepage into ground water. In addition, attenuation of minor, toxic constituents is effectively provided by organoclays in the subsurface. Nevertheless, the presence of large number of these ponds within the recharge zone of an aquifer that is widely used as a water supply may be a source of concern to overall water quality, but especially with respect to secondary criteria of the National Interim Drinking Water Standards, (e.g., chlorides and sulfates). Techniques have been developed for "fixing" sludge and ash to render them less soluble. Along with the use of pond liners to retard seepage, these should greatly reduce the danger of serious ground-water contamination. Otherwise, intensive lignite development could possibly lead to locally degraded conditions, and possibly foreclose the domestic use of ground water.

The permit requirements pursuant to the recent Resource Conservation and Recovery Act may be a mitigating factor if fly ash is judged to be a hazardous material, as is currently being debated. The permit would require a very detailed hydrogeologic investigation and monitoring plan at the ash disposal site before disposal would be approved. Again, however, no ground water contamination of any kind by ash disposal ponds has ever been demonstrated in the lignite region.

4.3.2 Alterations to Hydrodynamics

Altered hydrodynamic conditions in surface and subsurface waters may change the water quality. Perhaps the most important factor in this regard is consumptive use of water. The long-term retention of runoff in cooling reservoirs or settling ponds is similar to consumptive use in its effect. Both of these mechanisms decrease the flow that otherwise would be available in a drainage basin, and this is especially significant during low flow periods. The decreased flow is associated with a decreased assimilative capacity. In conjunction with the addition of pollutants by other mechanisms, this might result in decreased water quality for an indeterminate distance downstream of the lignite belt during lower flows.

Mining itself may temporarily reverse hydraulic gradients as a result of widespread seepage into the pit, and may be induced by dewatering practices. Also, backfilling of mines with disturbed material may reduce or increase flow through that area, resulting in steeper or flatter hydraulic gradients over a large area. In the lignite belt, this condition will probably be of only minor significance to water quality, since the different Leakage induced from other strata as a result of potentiometric changes is not likely to be very different on average than that which originally existed. Moreover, it seems unlikely that hydrodynamic velocity changes as a result of lignite utilization would be so drastic as to affect materially the attenuation potential or natural geochemical processes governing existing ground water quality.

4.3.3 Secondary Effects on Water Quality

As long as capacity is available in municipal systems, the wastewater generated by the increased urban population accompanying lignite development should not result in changes in treated effluent quality. However, the assimilative capacity of receiving streams may be taxed by the additional pollutant mass loadings (see also discussion of 4.3.2) which may result in reduction of dissolved oxygen concentrations to levels deleterious to aquatic biota. Especially in East Texas, numerous small towns will be the focus for population growth and will be required to provide expanded sewerage services with existing systems. Wastewater treatment facilities may be strained hydraulically or organically, at least in the short run, resulting in a treated effluent quality that is poorer than designed and probably inadequate to protect in-stream quality of the generally small receiving streams. This will be especially true if a number of communities with such problems discharge to the same stream system.

Population increases also suggest additional water pollution from leachates of sanitary landfills, septic tanks, and from urban runoff, but these incremental impacts are not considered significant at the regional level of this analysis.

4.3.4 Estimation of Aggregated Effects

Intensive lignite development will tend to decrease water quality of surface streams and ground water in the vicinity of the mine and power plant sites, and downstream of municipal outfalls. Direct effects of lignite utilization will tend to be manifested as increased dissolved solids. Secondary effects will probably be reflected in low dissolved oxygen in streams and increased eutrophication in downstream impoundments.

Most of these water quality impacts will not be observable in the near term. Even in the long term, the extent to which the impacts are significant will depend largely on the spatial distribution of the related activities within the lignite belt, and their relation to other features and activities. However, impacts on ground water quality may be of more serious concern than is currently envisioned, owing to the increasing reliance that must be placed on the ground water resource as a water supply for all future needs.

4.4 Cumulative Effects of Air Emissions

This analysis of cumulative air emissions from lignite development suggests that, despite favorable climatology, sulfur oxide-related effects may become appreciable by the year 2000 through large-scale, temporary plume interaction. The significant adverse impacts, if any, of these cumulative effects have not been specifically determined. However, it should be observed that the existing rules and regulatory policies, which are designed to protect human health and welfare against deleterious air quality, apparently will not practically prevent the intensive development of lignite envisioned in Section 2.4. In particular, such intensive development can evidently comply with all applicable New Source Performance Standards and new guidelines for prevention of significant air quality deterioration. The inference is that substantial adverse impacts to air quality will not occur. Nevertheless, by the year 2000, any additional development will probably exacerbate a trend toward regional air quality deterioration. Locally, prevailing air quality regulations may effectively prevent lignite utilization, especially in areas near the lignite belt.

The factors which affect the impacts of lignite development on the regional air quality are the air quality regulatory framework, the regional meteorology, and the sources of emissions. Each of these factors is described in the subsections below. Virtually no air quality data exist in the rural areas of the lignite belt, and ambient quality can not be related to existing emissions. Existing air quality data are restricted to criteria pollutants in urban areas surrounding the lignite belt. Consequently, detailed air dispersion modeling, even though largely in an uncalibrated mode, is the most accurate, current method of projecting air quality impacts of existing and future lignite development. However, this modeling is not within the scope of this project, so cumulative effects have been more qualitatively addressed.

4.4.1 Regulatory Framework

4.4.1.1 Emission Standards

Texas' emission regulations applicable to existing lignite-fired sources are much more stringent than current

Federal standards (see Table 4.4-1). However, except for NO_x, the Federal New Source Performance Standards (NSPS) are identical to those of Texas, and also are the same for either coal or lignite. Thus, even low sulfur coal holds no great advantage over lignite. At this time, no Federal emission regulation for NO_x exists for lignite-fired sources, while Texas recognizes a limitation of 0.7 pounds of NO_x per million Btu input. EPA has proposed a NSPS for NO_x from lignite-fired units of 0.6 pounds per million Btu. (The EPA NO_x NSPS for coal-fired units is 0.7, the same as Texas.)

However, all of these NSPS's, and especially that for particulates, are expected to be made more stringent by the 1980's. At the present time, it is reasonable to believe that the more efficient control technologies applied to new coal-fired units to meet more stringent NSPS will be applied to new lignite-fired units as well. Thus, air quality impacts are expected to be equivalent for the two kinds of plants. However, the associated impacts on media other than the atmosphere (e.g., water supply, water quality, solid waste) may be quantitatively different.

4.4.1.2 Prevention of Significant Deterioration

All areas with ambient concentrations lower than the Primary National Ambient Air Quality Standards (NAAQS) are subject to the Prevention of Significant Deterioration (PSD) (Section 127 of the 1977 Amendments). Under this section, the EPA regional offices, or the state agencies which have been delegated authority, must review major new stationary sources in 28 categories, including lignite-fired steam electric units with heat inputs greater than 250 million Btu per hour (about 20 MWe), for requisite approval to obtain permits to construct. The current approach to preventing significant deterioration of air quality consists of two parts. First, cumulative increases in ground-level concentration resulting from new sources commencing construction

TABLE 4.4-1

EMISSION STANDARDS FOR COAL AND LIGNITE-FIRED STEAM ELECTRIC UNITS WITH GREATER THAN 250 MILLION Btu PER HOUR INPUT

Pollutant	Existing Source Performance Standards (pounds of pollutants per million Btu input)		New Source Performance Standards (pounds of pollutants per million Btu input)	
	Federal[1]	Texas	Federal	Texas
Sulfur Dioxide	5.0	3.0	1.2	1.2
Total Suspended Particulates (TSP)	0.4 - 4.0	0.3	0.1	0.1
Nitrogen Oxides (NO_x) for Lignite Fired Boilers	---	0.7	---[2]	0.7

---

[1] Teknekron, Incorporated, Environmental Regulations Affecting the Utility Industry in Texas, April 3, 1975

[2] EPA has proposed a NO_x standard for lignite-fired units of 0.6 pound. The state standard of 0.7 pound applies to both coal and lignite.

or modification since January 1, 1975, may not exceed the increments set forth in the Amendments. These increments are given in Table 4.4-2. Second, the sum of baseline air quality plus the increment theoretically allowable under the law may not exceed the National Primary or Secondary Ambient Air Quality Standards. Thus, the full incremental increase will not be allowed in practice if it causes violation of the NAAQS.

Presently, PSD increments apply to total suspended particulates (TSP) and sulfur oxides. But the Administrator of EPA is required to promulgate regulations for prevention of significant deterioration from hydrocarbons, carbon monoxide, photochemical oxidants, and nitrogen oxides within two years of the enactment of the 1977 Amendments.

Baseline ambient air concentrations are nominally those of 1974, according to the Clean Air Act Amendments of 1970. Consequently, to determine what proportion of the increment is available for a proposed new source, it is necessary to account for the contributions of all other major sources brought on line since January 1, 1975. In most areas, these contributions must be calculated by detailed dispersion modeling.

In applying PSD, three classes of areas are recognized, each with different allowable increases of ambient air concentrations above the baseline concentration. Areas designated Class I are regions in which virtually any deterioration in air quality is considered significant, which essentially prohibits any major new sources within such areas. The new amendments specify certain mandatory Class I areas, but none of these fall on or near the lignite belt. In Class II areas, air quality deterioration normally accompanying moderate, well-controlled growth would be considered insignificant. All areas within the United States, except the mandatory Class I areas and areas

TABLE 4.4-2

PREVENTION OF SIGNIFICANT DETERIORATION: MAXIMUM ALLOWABLE INCREASES IN SO_2 AND TSP CONCENTRATIONS UNDED THE CLEAN AIR ACT ADMENDMENTS OF 1977[1]

Pollutant	Averaging Time	Maximum Allowable Incremental Increases ($\mu g/m^3$) Class I	Class II	Class III
Sulfur Dioxide (SO_2)	Annual Mean	2	20	40
	24-Hour[2]	8	91	182
	3-Hour[2]	25	512	700
Total Suspended Particulates (TSP)	Annual Mean	5	19	37
	24-Hour[2]	10	37	75

---

[1] All areas are desingated Class II except Mandatory Class I Areas.

[2] The 3-hour and 24-hour SO_2 and TSP concentrations may be violated not more than once per year.

designated Class I under previous PSD regulations, are Class II areas. The states can redesignate Class II areas either Class I or, within limits, Class III. In Class III areas, the maximum allowable increases are about half the National Primary Ambient Air Quality Standards, with the exception that the 24-hour maximum allowable increases may be exceeded once a year without contravening the standard.

Cumulative emissions from all new major sources brought on line since January 1, 1975, must not exceed the maximum allowable increases in the immediate vicinity of the proposed new source, or the applicable increases in adjacent areas within the "area of influence" of the proposed new source. The "area of influence", as presently defined by EPA Region VI, is the region around a source in which the source alone will not cause the maximum allowable increases for a Class I area to be exceeded. Two areas of influence for each source exist: one for SO_2 and another for TSP. Within a given area of influence, the increment is "used" on a first-in-time, first-in-line approval basis, until the increment is exhausted, after which no new sources can be approved. Technologically, the last user of an increment generally must have more efficient control technologies than the existing source(s) within the area, in order to not violate the allowable increment.

The allowable PSD increments for SO_2 and TSP are shown in Table 4.4-2. Significantly, the recent Clean Air Act Amendments have revised the 24-hour and 3-hour SO_2 increment for Class II areas downward from 100 to 91 $\mu g/m^3$ and from 700 to 512 $\mu g/m^3$, respectively.

4.4.2 Dispersion Potential in the Lignite Belt

The Texas lignite belt in general has few problems with large-scale poor dispersion conditions. When problems do occur, they are usually associated with a strong, stagnant high-pressure system with light winds. The mass of high-pressure air tends to sink, causing it to warm by compression as it nears ground level. This results in a temperature inversion characterized by low mixing depths. The light surface winds further reduce dispersion potential. Poor dispersion conditions of this kind may last for two or three days. The eastern half of the lignite belt experiences the most dispersion problems (relatively few in comparison, for air stagnation decreases from east to west across the region). The general dispersion conditions throughout the region are fairly good, partly because moderate surface winds and good thermal mixing are prevalent much of the time.

On the average, only about five periods of extended poor dispersion conditions (conditions requiring the issuance of an Air Stagnation advisory by the United States Weather Service) occur during the year. These Air Stagnation Advisories are issued mostly over the Southeast Texas region; only the extreme southeastern sections of the lignite belt are affected. These stagnation conditions most commonly happen during August, September, and October, although they can occur during any month of the year.

The air pollution potential of the Gulf Region will not be affected significantly by micrometeorological conditions, primarily because the terrain is basically flat and uniform. Tree canopies and other vegetation could diminish wind speeds and deflect wind directions slightly, but the mixing layer as a whole will not be affected. Only low-level dispersion will be affected by these terrain irregularities. Normally, power plant plumes exist at much higher elevations than near-surface, terrain-induced turbulence can reach.

Violations of both the primary and secondary state standards for particulate matter are unusual in the Texas lignite belt. Dust storms can raise ambient particulate levels in the spring months to levels which can exceed short-term criteria. However, blowing dust raised by large-scale meteorological condiitons is not counted in the air-quality data base. The highest potential for dust storm activity is in the southern and southwestern portions of the lignite belt. Dry conditions during the early spring and strong westerly frontal winds often bring dust from the West Texas plains into the region.

4.4.3 Emission Control Technology

Both lignite and coal combustion will now require the use of BACT. At least in the near term, this means flue-gas desulfurization (scrubbers) and some form of particulate control. Texas has established a visibility standard (20 percent opacity), in addition to particulate emission rates. The visibility standard usually is the more stringent of the two. The Texas Air Control Board has required one power plant to install fabric filters in addition to conventional electrostatic precipitation (ESP), to enable it to meet this standard.

There may be a number of differences between Texas lignite and western or mid-western coal which might significantly affect their SO_2 and particulate emissions. The most apparent of these are:

- Heating value
- Trace metal content
- Ash content
- Ash resistivity

For a power plant of fixed size, the amount of flue gas generated by burning lignite should be roughly equal to that generated by burning coal. This is true because the air rate is determined by the desired carbon-burning rate (heat rate), which is approximately equal for all fuels. The physical sizes of required sulfur dioxide scrubbers and fabric filters are determined more by gas volume than any other single parameter. We can then conclude that the size of sulfur dioxide scrubbers and fabric filters required will not be significantly different if lignite or coal is used as a fuel. While the actual scrubber size is generally independent of the fuel, the scrubber's ancillary equipment may well not be. The size of this equipment (pumps, storage tanks, clarifiers, filters, etc.) depends more upon the quantity of sulfur to be removed. This quantity will, in all likelihood, be greater for lignite than for coal, since lignite contains more sulfur per Btu than most western coals.

Thus, the magnitude of the solids disposal problem will be greater for lignite than coal. Three factors are responsible:

- The amount of sulfur to be scrubbed (on an equal power basis) is most likely greater for Texas lignite than for coal.

- The amount of ash produced (on an equal power basis) will be greater for lignite than for most coals.

- The trace metals composition of lignite may well be greater than for most coals. This will result in a greater concentration of such objectionable metals as mercury and arsenic in the ash/solids to be disposed of.

However, solid waste transportation may be less of a problem for those lignite-fired generating stations which can be located at the mine-mouth, where at least some of it can be buried during reclamation.

While the size of a fabric filter would not seem to depend as much on the choice of fuel, the case for electrostatic precipitators (ESP's) may be different. The size of an ESP is governed by the gas volume and a parameter known as the migration velocity. The migration velocity in turn depends upon the particle size, shape and electrical resistivity. Appropriate electrical resistivities for efficient ESP operation are generally given as 10^{10} ohm-cm to 10^{7} ohm-cm (SO-004). There is a range of sulfur content that corresponds to this "window". Below this range, resistivity can tend to increase to the extent that, for very low sulfur fuels, some chemical treatment of the flue gas may be necessary for efficient ESP operation (SO-005).

It is also true that ash resistivity can be correlated with the content of such metals as sodium and lithium (BI-035). This too may cause the resistivity of lignite ash to be inappropriately for optimal ESP operation, and therefore require utilization of fabric filters for achieving stringent particulate emission standards.

The physical properties and leaching potential of a mixture of ash and scrubber sludge has been shown to be a very strong function of the site-specific nature of the fuel being burned. It is quite possible that a mixture of lignite ash and sulfur sludge would behave differently than a similar mixture produced with coal ash. No generalizations can be drawn without designating specific fuels, however, as to which mixture might be the most desirable.

The possible differences between emission controls for coal and lignite-fired steam stations can then be summarized as follows.

- The size of ancillary equipment may be larger for lignite-fueled plants, although the physical size of sulfur scrubbers and fabric filters should be about the same.
- The solids disposal problem will be aggravated for lignite-fueled plants inasmuch as the amount of material to be disposed of will be larger and its objectionable trace metals content may well be greater.
- The required amount of suitable land for solids disposal will probably be greater for lignite-fueled plants than for coal.
- The size of ESP's required may be larger for lignite than for coal (or chemical treatment of the flue gas may be necessary) if extreme values of ash resistivity are encountered.
- Except for size and material handling problems, no significant difference is expected in the cost or problems associated with the operation of sulfur scrubbers, fabric filters, or electrostatic precipitators.

- The physical behavior and leachate potential of ash/sludge mixtures is extremely dependent upon the specific fuel being used; large differences can be expected, but no accurate generalizations can be drawn until specific fuels have been identified.

4.4.4 Impacts on Air Quality By Emissions from Existing Sources

Because of the lack of monitoring data, existing air quality impacts must be described largely by inference. Lignite-fired steam electric stations are not expected to have a significant effect on the carbon monoxide (CO) and nitrogen oxides (NO_x) concentrations in the region or in the urban areas around the lignite belt, where these pollutants are of more concern. Most of these CO and NO_x ground-level concentratons arise from motor vehicles. Hydrocarbon emissions from the lignite-fired units will be controlled to very low levels by boiler firing practices, and are not expected to produce adverse impacts on ambient air quality. Consequently, the discussion of air quality and emissions focuses on SO_2 and particulates.

The primary souces of SO_2 in the lignite region are lignite-fired steam electric stations and production of oil and gas. The emissions from oil and gas production are relatively small compared to the power plant emissions, but they generally have much greater effect on ground level air quality in the immediate vicinity of well fields, because they are emitted at low release heights and have low plume buoyancy. The SO_2 emissions from the lignite-fired units in operation in 1975 (see Figure 2.2-2) were approximately 190,000 tons per year.[1] However, because of the large distances between these stations, their cumulative impact on regional air quality is considered negligible.

The air quality impacts of fugitive particulate emissions from mining and processing the lignite are generally limited to the vicinity of the mine. All existing lignite mines are in East Texas and eastern Central Texas, where the rainfall is sufficient to limit the periods in which fugitive dusts can arise.

The existing lignite-fired steam electric stations in 1975 had particulate emissions of about 22,000 tons per year. The cumulative impact on current regional air quality is again believed to be negligible. The relative contribution of the lignite-fired stations to ambient particulate concentrations is expected to be much less than for SO_2. First, particulate emissions are typically an order of magnitude less than SO_2 emissions. There will also be a large number of other substantial sources releasing particulates at low levels. To determine more accurately the impacts of the lignite stations on particulate air quality, all point and area sources in the lignite belt would have to be inventoried and analyzed in detail.

---

[1] The SO_2 and particulate emissions were calculated using the annual emission rates of Big Brown and Sandow stations in the 1973 Texas Air Control Board Emission Inventory. The Monticello Units 1 and 2 were calculated assuming the units complied with Federal New Source Performance Standards (NSPS) and had a heat rate of 10,000 Btu/lb, and 70% load factor. The lignite was assumed to have a heating value of 7,135 Btu's per pound.

4.4.5 Cumulative Impacts of Future Lignite Development

4.4.5.1 Basis of Impact Determination

In order to place the air quality impacts of future lignite development into a temporal perspective, two time intervals have been selected: from the present to 1985, and from 1985 to 2000. Because it takes roughly seven years to design and build a lignite-fired unit, many of the units that will be operating by 1985 have been announced and their locations declared. However, little information is available on the size and location of lignite units to come on line after 1985, because utilities are unwilling to make firm commitments within the present fuel-related uncertainties.

The impacts discussed below are based on new lignite-fired steam electric stations consisting of two typical 750 MWe units equipped with flue gas desulfurization systems and about 450-foot stacks. Each boiler will burn lignite ranging from 6,500 to 7,500 Btu's per pound, and will have a stack exit temperature of 165°F. From an air quality standpoint, this station may be considered a reasonable worst case; therefore, the impact is conservative.

SO_2 emissions from such a plant will generally produce ground-level ambient concentrations that are less than half the federal primary and secondary 3-hour and 24-hour standards. The maximum short-term ground-level concentrations near the station will occur when the plume is trapped below an inversion. At greater distances from the station, the highest short-term ground-level concentrations will occur during persistent temperature inversions with steady winds blowing in a line with the sources.

A significant qualifying factor that should be recognized is that the model used to predict downwind concentrations becomes inaccurate at large distances from the station. The Gaussian plume dispersion model presently accepted by EPA becomes inaccurate beyond 50 kilometers (31 miles). The model also fails to account for decreases in pollutant concentrations associated with pollutant transformation and removal processes, such as dry deposition and chemical transformation. Finally, there are insufficient reliable dispersion data to determine both the horizontal and vertical spread of plumes at these distances from the source.

In the southwestern portion of the lignite belt, which generally contains lower-quality lignite and also has lower annual rainfall, the potential for fugitive dust is higher. However, the mine operators will dampen the haul roads to minimize the formation of fugitive dust, and use dust-suppression systems to control the emissions from lignite handling. The handling of lignite for mine-mouth steam electric stations typically does not include processes that heat, wash, or blow air upon the lignite, or involve discrete air emission sources. At handling facilities, such as hoppers, silos, stackers, and crushers, dust suppresion systems dampen the lignite for dust control. Also, the dust collection systems are generally used at transfer points to minimize dust release from lignite handling.

4.4.5.2 Lignite Development to 1985

A large expansion of lignite-fired steam-electric generating capacity has begun in Northeast Texas, as is discussed in Section 2.2. Not all of the new units, however, are subject to the PSD review by EPA. The proposed new units at the Martin Lake Station (2250 MWe), described in Table 4.4-3, will need to meet NSPS standards only.

TABLE 4.4-3

PROPOSED LIGNITE-FIRED STEAM ELECTRIC STATIONS NOT REQUIRED TO OBTAIN PSD APPROVAL FROM EPA

Municipal Utility System	Station Number and Number	County	City/Town	Capacity (MWe)	Date On Line
Texas Utilities Services, Inc.	Martin Lake #2	Rusk	Tatum	750	1978
	Martin Lake #3	Rusk	Tatum	750	1979
	Martin Lake #4	Rusk	Tatum	750	1983
			TOTAL	2,250	

TABLE 4.4-4

PROPOSED LIGNITE-FIRED STEAM-ELECTRIC STATIONS WITH KNOWN SITES AND WHICH ARE REQUIRED TO OBTAIN PSD APPROVAL FORM EPA

Station/Number	Principal Utility System	County	City/Town	Capacity (MWe)	Year of Start-Up	Buffer Distance (mi)
Monticello #3	Texas Utilities Services, Inc. (TUSI)	Titus	Mt. Pleasant	750	1978	15
San Miguel #1	South Texas and Medina Electric Cooperatives & Texas Municipal Power Agency	Atascosa	Jourdanton	400	1979	16
#2		Atascoas	Jourdanton	400	1984	
Sandow #4	TUSI	Milam	Rockdale	545	1981	11
Gibbons Creek						
#1	TMPA	Grimes	Carlos	400	1985	16
#2		Grimes	Carlos	400	1982	
Forest Grove						
#1	TUSI	Henderson	Athens	400	1982	8
Twin Oak #1	TUSI	Robertson	Franklin	562	1984	22
#2		Robertson	Franklin	562	1985	
South Hallsville	SW Electric Power Cooperative	Marion	Longview	660	1985	13

TABLE 4.4-5

PROJECTED LIGNITE-FIRED STATIONS WITHOUT LOCATION SPECIFIED

Principal Utility System	Capacity (MWe)	Date On Line
Houston Lighting and Power	750	1982
City Public Service Board of San Antonio	375	1983
Lower Colorado River Authority	750	1985
TOTAL	1,875	

Utilities have proposed an additional 6,954 MWe of lignite-fired generating capacity, to be operating by 1985. All of these units are required to have PSD approval by EPA to obtain permits to construct. Presently seven new lignite-fired stations (or new units), with a total capacity of 5,079 MWe, have announced plant sites and already have or will apply for PSD review. These are listed in Table 4.4-4. The sites for the remaining 1,875 MWe proposed to be operating by 1985 have not been announced; data on these units are presented in Table 4.4-5.

These lignite-fired stations, including both existing and proposed units, are projected to emit about 550,000 tons of SO_2 and 51,000 tons of particulates per year. This approximately three-fold increase in emissions is not expected to affect significantly the annual average concentrations of TSP or SO_2 in the lignite belt. Of more concern are possible plume interactions with new stations built in the lignite belt.

One method of assessing the cumulative short-term air quality impacts of the future lignite development is to evaluate whether such development can occur without exceeding applicable PSD increments for the worst-case conditions. If this is possible, potential problems with cumulative air quality impacts from lignite development are not likely to exist. All of the lignite belt is designated as a Class II area. However, the proposed Big Thicket National Wildlife Preserve may be designated as Class I. A Class I designation of this wildlife preserve may limit the size or location of the mine-mouth steam-electric stations in the East Texas portion of the lignite belt.

The minimum distance between two lignite-fired stations that will cause no significant interaction of their plumes to occur is determined by the short-term SO_2 concentrations. (The maximum annual SO_2 concentration will be less than the allowable Class II increments, and generally occurs too close to the source for it to interact with another.) The maximum ground-level concentrations of particulates from such stations are everywhere less than the Class I increment, and could therefore interact without exceeding PSD increments. The maximum short-term SO_2 concentrations caused by two interacting sources occurs when the wind direction is aligned with the sources. Using this worst-case configuration, the air quality degradation may be modeled under worst condition assumptions to define the distance separating any two plants which negates the particular Class II increment being violated by the interaction of the two plumes.

This distance, of course, varies with the sizes of the two stations being considered and with their physical and operating characteristics (e.g., stack heights and exit temperatures). For two 1,500 MWe stations with the reasonable worst-case characteristics described above, this distance is about 30 miles for the 24-hour increment, and 18 miles for the 3-hour increment. Hence, the 24-hour increment is the more limiting case. Under these conditions, a separation of 30 miles is a rough guideline for insuring that no significant plume interactions occur. Since modeling limitations prevent making reliable predictions over larger distances, it would be difficult to justify a greater separation.

It should not be construed that two power plants cannot be located closer than 30 miles. The operating conditions applicable to the 30-mile guideline represent the worst case, which may occur no more than once per year. The PSD regulations allow the increment to be exceeded once per year, which in effect ignores violations caused by such rare meteorological conditions. Thus, the 30-miles separation is not strictly a practical restriction needed to assure compliance with regulations. Rather, it reflects the absolute potential for plume interactions.

The 30-mile separation is applicable to two 1,500 MWe stations. To calculate the distance between such a new unit and another unit of different size, this 30-mile distance was linearly proportioned to the ratio of the power output of the other unit and the 1,500 MWe output of the new station. In this manner, areas of significant potential plume interaction with a new 1,500 MWe plant were defined for those plants with known locations (Figure 4.4-1). To the extent that future lignite utilization is located outside these areas around planned units, significant plume interaction and cumulative air quality effects will not occur.

Figure 4.4-1 indicates that a number of locations are available outside these areas for additional 1,500 MWe mine-mouth stations in the lignite belt between Milam County, northeast of Austin, and Van Zandt County, east of Dallas. For example, a station larger than 1,500 MWe could be constructed in Bastrop County in the Camp Swift area without plume interaction to a significant degree. Also, several more mine-mouth stations could be located in the northernmost areas, where the lignite quality is highest. And mine-mouth stations can be sited almost anywhere along the southwestern part of the Wilcox trend or on the Yegua-Jackson trend, except around the San Miguel station. These available sites are probably sufficient to accommodate the unsited capacity planned through 1985. If these plants can be sited in the "available" zones and still lie close enough to the end-use demand centers they are planned to serve, significant cumulative air quality impacts may be avoided through 1985.

4.4.5.3 Lignite Development to 2000

Beyond those units on line in 1985, between 7 and 21 more (1,500 MWe) stations are projected to satisfy estimated electrical power demands in the year 2000 (see Section 2.4). The SO_2 emissions from all lignite-fired sources are estimated to range from 880,000 to 1,500,000 tons per year in the year

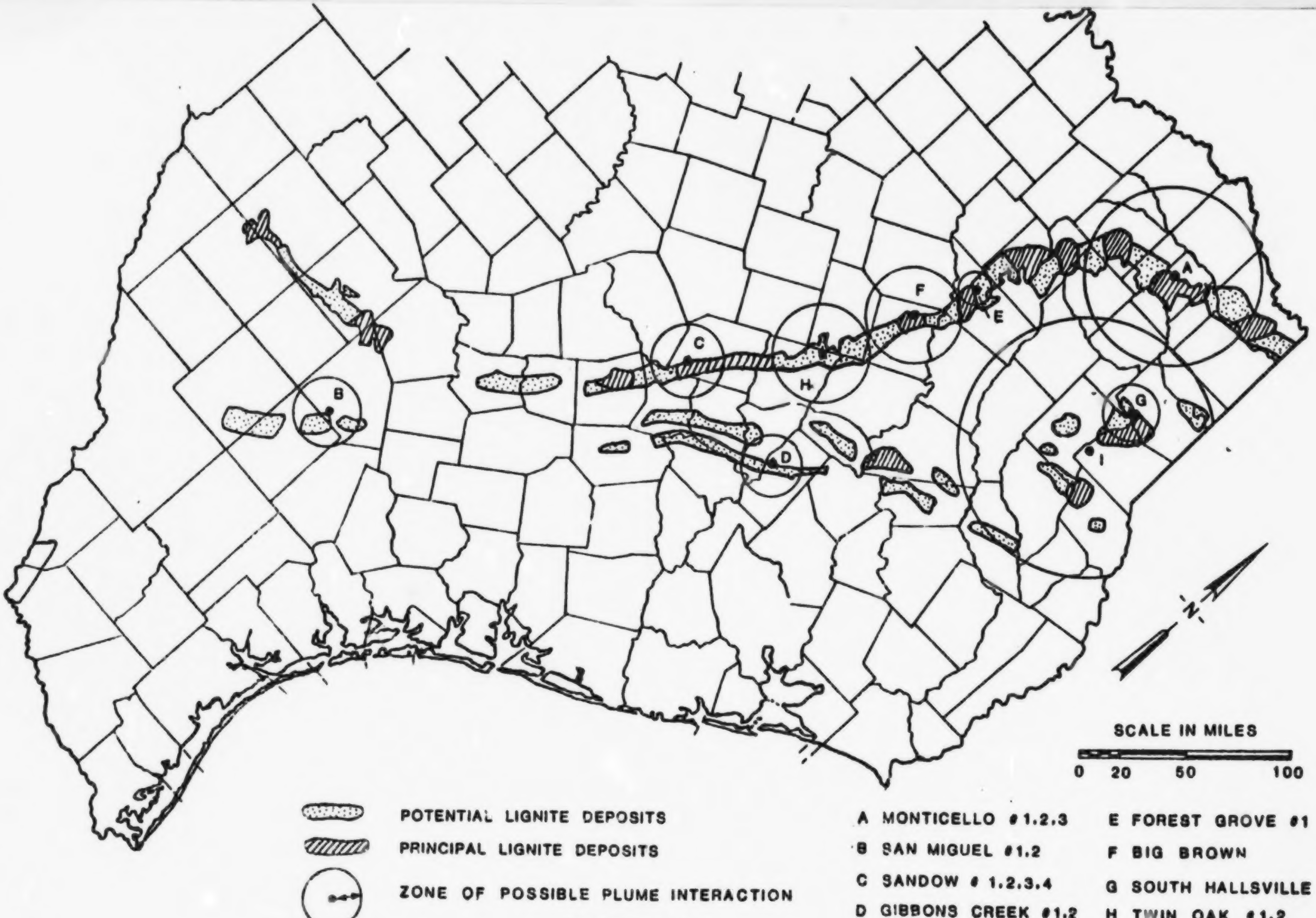

A
B
C
D
E
F
G
H
I
SCALE IN MILES
0
20
50
100
N
POTENTIAL LIGNITE DEPOSITS
PRINCIPAL LIGNITE DEPOSITS
ZONE OF POSSIBLE PLUME INTERACTION
A MONTICELLO #1.2.3
B SAN MIGUEL #1.2
C SANDOW # 1.2.3.4
D GIBBONS CREEK #1.2
E FOREST GROVE #1
F BIG BROWN
G SOUTH HALLSVILLE
H TWIN OAK #1.2
I MARTIN LAKE # 1.2.3.4.

FIGURE 4.4-1

LIGNITE-FIRED POWER PLANTS WITH KNOWN SITES, SHOWING ZONES OF POSSIBLE SIGNIFICANT PLUME INTERACTION

02-2082-1

2000 for the low and hihg development cases, respectively. This rise in SO_2 emissions conceivably may cause a small increase in SO_2 concentrations measured at urban centers of the lignite belt by 2000. The associated particulate emissions would increase to between 95,000 and 150,000 tons per year for the two cases. Since this increase in particulate emissions is only one tenth that of SO_2, a large increase in particulate concentrations is not expected to occur in any of the urban areas of the lignite belt.

The emission projections as a function of time are summarized in Table 4.4-6.

As seen in Figure 4.4-1, about ten new mine-mouth lignite-fired stations may be the maximum number of new station sites within the lignite region without risking adverse plume interactions. This condition is not of much concern to the lower bound of estimated lignite demand, requiring seven such stations. But clearly, the 21 new station required to accommodate the upper bound may not be sited at the mine-mouth without incurring a substantial risk of adverse plume interaction unless SO_2 control efficiencies or plant characteristics are greatly modified. Indeed, in some areas, the PSD regulation may effectively prevent lignite utilization at the mine mouth. Fuel transportation costs will increase if lignite is moved far away from its original location. Also, output power penalties associated with increased SO_2 control will be economically important. These factors will provide impetus for continued mine-mouth siting, thus increasing the risk of some air quality deterioration over much of the lignite belt. The ability of a particular power plant to meet PSD regulations at a particular site can only be adequately determined with site-specific, detailed air quality dispersion modeling.

TABLE 4.4-6

ANALYSIS OF SO_2 AND PARTICULATE EMISSIONS FROM LIGNITE-FIRED STEAM ELECTRIC STATIONS

	1975[1]	1985	200	
			Low	High
Installed Lignite-Fired Steam Electric Stations	2,660	12,614	21,400	42,800
SO_2 Emissions (Million Tons Per Year)	0.19	.55	0.88	1.5
Particulate Emissions (Million Tons Per Year)	0.022	0.051	0.095	0.15

---

[1] These SO_2 particulate emissions were calculated using annual emissions of Big Brown Station and Sandow Station in 1973 Texas Air Control Board Emission Inventory. The emissions from Monticello Units #1 and #2 were assumed to comply with federal New Source Performance Standards and have lignite and plant operating characteristics of prototypical plant.

4.5 Changes in Land Use

Lignite development in Texas will affect land use at several levels. There will be direct changes due to the surface mining, the subsequent reclamation, and the construction of large power plants. Also, there will be indirect effects accompanying population growth. The actual changes are site-specific, yet some general statements can be made.

4.5.1 Direct Effects

Surface mining of lignite will affect land which is now mostly in agricultural use, timberland, or open range. Compared to other agricultural land in Texas, its productivity is low. Once the mining operations have been completed, the land will have been reclaimed in accordance with the requirements of the new Federal surface mining act. Experience to date suggests that these mined lands, properly fertilized and managed, may actually be more productive agriculturally than before.

Reclamation in Texas is primarily dependent upon climate, topography, soils and overburden, and geohydrology. Radian has performed an in-depth analysis (GA-R-242) of the variations in reclamation potential throughout the Texas lignite belt. This study weighted each of these factors in a parametric model. The results of that analysis are shown in Figure 4.5-1.

The Texas lignite belt was subdivided into eleven regions based upon soil associations proposed by the Soil Conservation Service. The reclamation potential of each region was estimated. Four major classifications were possible:

Class I: No limitations on reclamation.

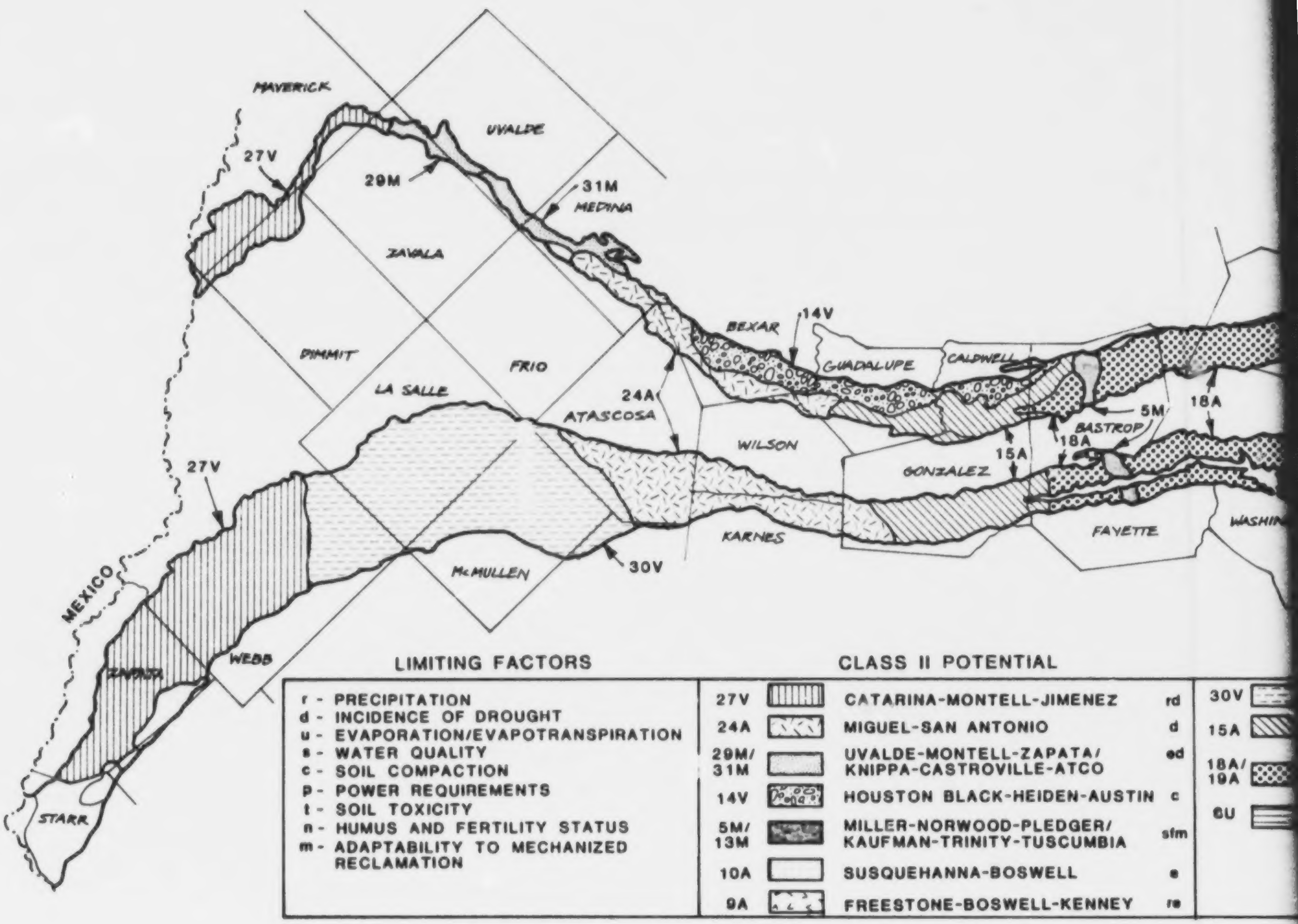
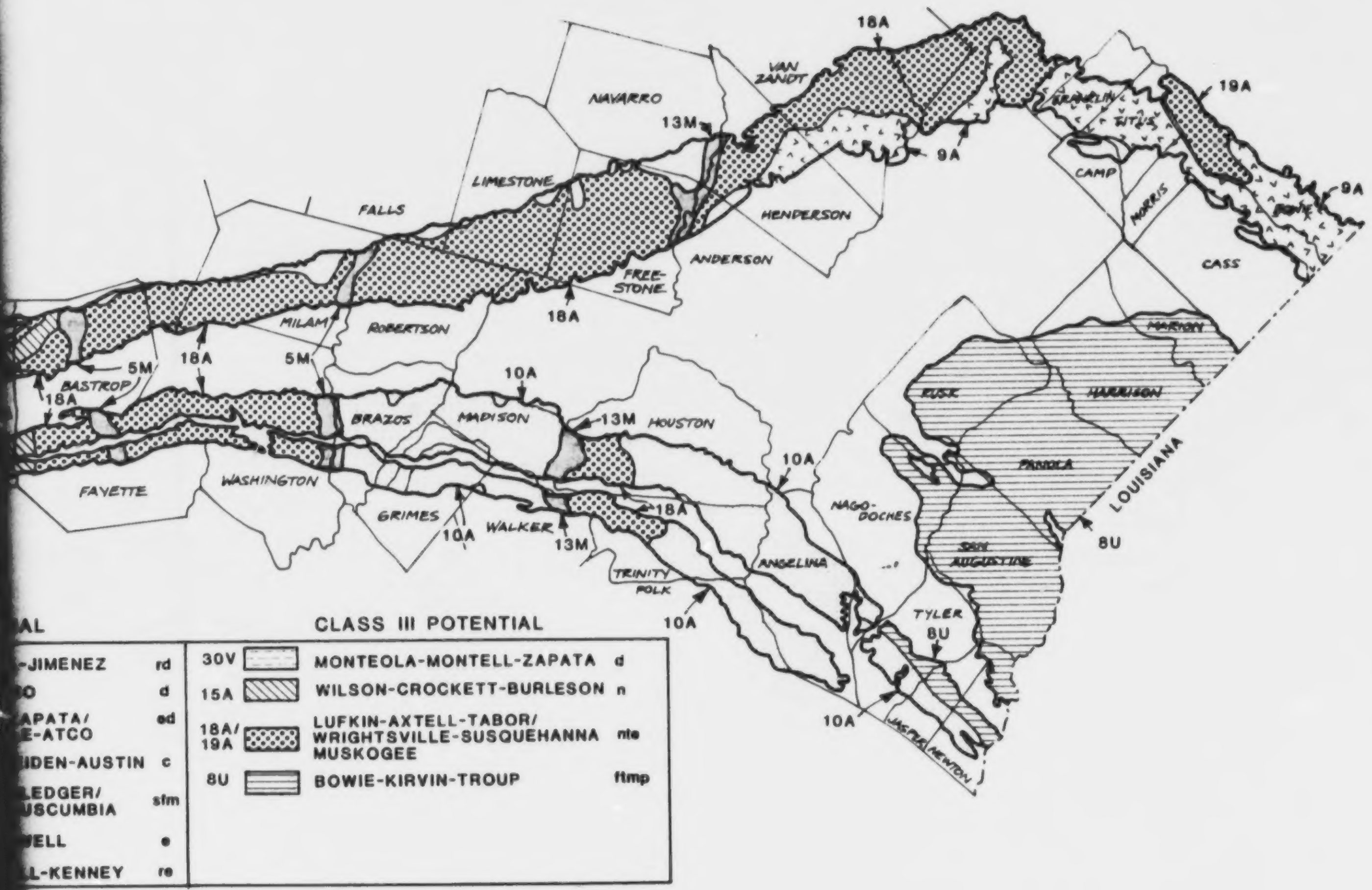

MAVERICK
UVALDE
27V
29M
31M
MEDINA
ZAVALA
DIMMIT
LA SALLE
FRIO
BEXAR
14V
GUADALUPE
CALDWELL
24A
ATASCOSA
WILSON
5M
18A
BASTROP
18A
15A
GONZALEZ
27V
KARNES
FAYETTE
WASHIN
30V
McMULLEN
MEXICO
WEBB
ZAPATA
STARR
LIMITING FACTORS
r - PRECIPITATION
d - INCIDENCE OF DROUGHT
u - EVAPORATION/EVAPOTRANSPIRATION
s - WATER QUALITY
c - SOIL COMPACTION
p - POWER REQUIREMENTS
t - SOIL TOXICITY
n - HUMUS AND FERTILITY STATUS
m - ADAPTABILITY TO MECHANIZED RECLAMATION
CLASS II POTENTIAL
27V CATARINA-MONTELL-JIMENEZ rd
24A MIGUEL-SAN ANTONIO d
29M/31M UVALDE-MONTELL-ZAPATA/KNIPPA-CASTROVILLE-ATCO ed
14V HOUSTON BLACK-HEIDEN-AUSTIN c
5M/13M MILLER-NORWOOD-PLEDGER/KAUFMAN-TRINITY-TUSCUMBIA sfm
10A SUSQUEHANNA-BOSWELL e
9A FREESTONE-BOSWELL-KENNEY re
30V
15A
18A/19A
6U

FIGURE 4.5-1

RECLAMATION POTENTIAL OF THE TEXAS



18A
VAN ZANDT
19A
NAVARRO
13M
FRANKLIN
TITUS
9A
LIMESTONE
CAMP
MORRIS
9A
FALLS
HENDERSON
BOWIE
ANDERSON
CASS
FREE-STONE
18A
MILAM
ROBERTSON
MARION
5M
18A
5M
BASTROP
18A
10A
RUSK
HARRISON
BRAZOS
MADISON
13M
HOUSTON
PANOLA
FAYETTE
WASHINGTON
10A
NAGO-DOCHES
LOUISIANA
GRIMES
WALKER
18A
10A
13M
8U
SAN AUGUSTINE
TRINITY
POLK
ANGELINA
10A
TYLER
8U
10A
JASPER
NEWTON
AL
-JIMENEZ rd
O d
APATA/ E-ATCO ed
IDEN-AUSTIN c
LEDGER/ USCUMBIA sfm
ELL e
L-KENNEY re
CLASS III POTENTIAL
30V MONTEOLA-MONTELL-ZAPATA d
15A WILSON-CROCKETT-BURLESON n
18A/ 19A LUFKIN-AXTELL-TABOR/ WRIGHTSVILLE-SUSQUEHANNA MUSKOGEE nte
8U BOWIE-KIRVIN-TROUP ftmp

URE 4.5-1

AL OF THE TEXAS LIGNITE BELT

02-1639-4

Class II: Slight limitations, little management and control required.

Class III: Moderate limitations, some management and control required.

Class IV: Severe limitations, extensive management and control practices required. Problems may not be solvable with available resources.

Figure 4.5-1 shows that all the relatively large regions into which the lignite belt has been divided are either Class II or Class III. The use of smaller regions would probably have revealed Class I and Class IV areas. However, for the present effort, these eleven regions give a good idea of reclamation potential.

Within each region in Figure 4.5-1, the limiting factor(s) are labeled. Obviously, lack of water is a major factor. However, much of the area where water is not a problem is Class III. Thus, reclamation is limited by a wide variety of factors.

In general, Class II regions are moderately suitable for reclamation in cultivated crops, pasture, and forestry. Class III areas will be more difficult to vegetate and the cost will be higher. Thus, reclamation for productive land in most areas of the Texas lignite belt is feasible, but it will be expensive and require thorough planning.

Power plants will also require land to be removed from current uses. However, these plants are not constrained to a particular geographical location. In fact, some lignite-fired plants will probably be located at some distance from the lignite belt (see Section 4.4). Hence, the impact of siting on land quality cannot be adequately addressed. In general, however, land on either side of the lignite belt is more profitable agriculturally than the lignite belt itself. Therefore, power plant sites off the lignite belt will remove better land from production. Furthermore, this type of land use change is more likely to occur near the year 2000, when the value of agricultural land will be higher because of the loss of prime agricultural land to urban and industrial uses.

The actual acreage lost varies from plant to plant. However, even if 26 new plants are built at 2000 acres each (including cooling pond), only 52 000 acres will be lost to current use. Spread out along the entire lignite belt, this does not represent a great amount of land.

4.5.2 Indirect Effects

As a result of the economic stimulation related to lignite development, thousands of families will choose to settle in nonmetropolitan areas. Many of these people would probably be tied economically to metropolitan areas if lignite development does not increase. It may be more efficient from a national perspective to disperse population from metropolitan areas to small towns in nonmetropolitan areas like the Texas lignite belt.

As discussed in Section 4.1.5, the cost of services in nonmetropolitan areas is less than in metropolitan areas. In addition, there is probably a considerable amount of unfilled capacity in many nonmetropolitan towns in Texas, where outmigration has prevailed for decades. Nonmetropolitan development may relieve some of the pressures which exist in metropolitan areas, particularly the suburban sprawl type of land use development.

In conclusion, the conversion of agricultural land or open space near the lignite belt to urban land use (residential, commercial, etc.) may be in the national interest. At the local level, it may appear to be an adverse consequence; however, from a broader perspective, it will help to save land around cities that are already too large geographically. The environmental costs of urban sprawl (RE-118) are great, and nonmetropolitan development in Texas, based upon lignite, may help reduce those costs.

4.6 Cumulative Biological Impacts

4.6.1 Impacts on Terrestrial Communities

The terrestrial impacts caused by lignite development in Texas can best be characterized by discussing the types and amounts of wildlife habitat affected. Previous sections have hypothetically forecast both upper and lower boundary conditions for lignite mining, electric power generation, and secondary urban development brought on by lignite development. These scenarios are projected for the years 1985 and 2000. Assuming each lignite mine supplies fuel for a 1500 MWe steam electric generating plant which operates at 60 percent capacity, about 15,000 tons of lignite per day would be consumed. At 12,500 tons per acre this would mean about 1.2 acres per day or 438 acres per year would be mined for each such generating facility. This corresponds roughly to 7,100 Btu/lb lignite with an average seam thickness of 6 feet. Texas lignite varies typically from 5,500 to 7,500 Btu/pound and from 2 to 20 feet aggregate thickness.

By the year 1985 only those mines and generating stations presently planned could be operational. This means a maximum of 9 mine/power plants distributed as shown in Figure 5.1-1. An additional 2000 acres will be used for the power plant, cooling pond, haul roads, coal handling facilities, etc. By 1985 these nine facilities will have used about 18,000 acres for facilities and could be mining 3,942 acres annually. Within their 30 year-life spans they could affect a total of about 136,260 acres.

By the year 2000, the forecast's upper bound, with all new power generation using lignite, calls for 30 lignite mines with associated power plants, or an increase of 21 over the 1985 conditions. This could mean a maximum of 60,000 acres used for facilities at an annual mining rate of 13,140 acres. Within their 30-year life span these 30 mine/power plants could affect a total of 454,200 acres of land. The lower bound, with half of all new power generation using lignite, calls for a total of 16 mine/power plants by 2000. These would use 32,000 acres for facilities, mine 7,000 acres annually and could affect 242,200 acres in their 30-year life span.

From these calculations it can be deduced that the Texas lignite belt can look forward to the mining of about 3,940 acres per year by 1985 and between 7,000 and 13,000 acres per year by 2000. Also, within the 30-year planned lifetimes of the mine/power plants, between 242,000 and 454,000 acres of land could be affected. Since the majority of the power demand, available surface water, and best lignite deposits are all located in the eastern portions of the lignite region, it has been projected in previous sections that most of the development will occur generally northeast of the Colorado River.

Accompanying the direct effects of lignite development will be indirect effects caused by the creation of a maximum of 97,000 new jobs and significant numbers of new people moving into the lignite area. Since people may commute 50 miles or more to work in the semi-rural areas, the distribution of these new families and, therefore, the location of the land used by their houses, etc., is difficult to predict. As noted in previous sections, most of the increased population is expected to settle in the existing small communities throughout the lignite belt, thereby causing little disturbance to the more remote wildlife habitats.

The direct effects of the lignite mine/power plant units on the terrestrial wildlife habitats and resources of the lignite region will be minimal when viewed on an individual basis. Each individual mine plus 1500 MWe power plant will use about 2000 acres of land (possibly wildlife habitat) during its 30-year life span for facilities. Since mining will be linear in nature, no more than about 1,500 acres should be disturbed at any one time. This will include land cleared of vegetation prior to mining, the mine area, and land in the first stages of reclamation prior to the establishement of vegetative cover. For this reason the actual long-term impacts on the wildlife habitat depend totally upon the type of reclamation planned and the speed at which it is effected. Wildlife habitat is currently fragmented over much of the eastern portion of the lignite region, as a result of 100 years of farming and ranching. It is therefore possible to reclaim mined land so that its wildlife carrying capacity will be greater than under current conditions. The wildlife value of average native pastures and improved Bermuda grass pastures is quite low due to the lack of food and shelter that are usable by wildlife. Few species can live in a monoculture of Bermuda, especially if it is cut or grazed prior to setting seeds. Bermuda is a good cattle food but a very poor food for wildlife. By replacing the unpalatable species in the average pasture and the Bermuda grass in the improved pastures with native grasses, the wildlife habitat value can be enhanced considerably. Many species of rodents and seed-eating birds, including the mourning dove and bobwhite quail, will live in the native grasses. And, if brush edges and woodlands are replaced, while-tailed deer will also inhabit the area. The mining of large areas of mature forests would destroy more valuable wildlife habitat for a longer period of time than the mining of the same amount of heavily grazed pasture land. Assuming, however, that only a minor portion of each mine site contains relatively mature forests (this is a valid assumption for most of the Texas lignite region), the cumulative direct impacts of lignite mining and the accompanying electric power generation would be equal to the sum of the individual impacts unless some interaction between mines occurred. The Pineywoods, Post Oak Savannah, and South Texas Plains vegetation/wildlife habitat regions, under which the lignite is found, occupy approximatley 15 million acres, 8.5 million acres, and 20 million acres, respectively. The upper bound of the lignite forecast could affect only about one percent of the total available habitat over its entire 30-year life span. Even is this figure is nearly doubled by assuming that most of the lignite development will occur in the 23.5 million acres of the Pineywoods and Post Oak Savannah regions east of the Colorado River, it is still a very small percentage. In actuality, at the upper bound of 30 mine/power plants, only 13,100 acres or 0.056 percent of the Pineywoods and Post Oak Savannah habitats would be mined annually by the year 2000. Using 1,500 acres per mine as the amount of land cleared at any one time (exclusive of facilities), a total of 45,000 acres or 0.19 percent of these habitat regions would be cleared at any point in time. By simple deduction it can be seen that even the maximum of 30 mine/power plants could have little short-term and even less long-term (after reclamation) effect on the overall terrestrial wildlife habitat and associated wildlife resources of the Texas lignite region.

No doubt lignite mining will have some ecological effects since any further destruction of the already fragmented wildlife habitats will be detrimental to the existing wildlife populations. It is simply doubtful that the direct and indirect effects of lignite mining and its accompanying development will cause significant or even measurable changes in the overall terrestrial wildlife populations of the region.

The sensitive areas discussed in Chapter Three should not be greatly affected. Most of the sensitive areas could be designated under the Federal Surface Control and Reclamation Act of 1977 as unminable. The areas of riparian woodlands could be affected but this will depend upon the location and mining plan for each specific mine.

4.6.2 Impacts on Aquatic Communities

The aquatic impacts of future lignite development in Texas can be categorized as either water-quality or water-quantity related. These two broad categories sometimes interact to cause impacts such as concentration of water-borne material due to evaporation and low flow conditions during droughts. Changes in the aquatic biota associated with water-quality and water-quantity changes derived from lignite development are difficult to quantify except on the most gross scale. Previous sections of this chapter have generally discussed the water quality and quantity changes expected throughout the Texas lignite region.

It is beyond the scope of this study to discuss in detail all possible site-specific changes in the aquatic biota directly and indirectly associated with lignite mining and power generation. However, it must be noted that some of the possible adverse impacts on the aquatic biota will result from site-specific changes that may not be significant on a regional level. As discussed in previous sections, water quality changes from construction, mining, and increased urban runoff, thermal loading, and stack emissions interacting with the surface water, may cause possible minor site-specific changes in the aquatic plant and animal populations. The exact nature and extent of these must be analyzed on an individual basis.

Cumulatively, the combination of future industrial and domestic demand, which together may consume a maximum of about 43,000 acre-feet of water per year, should not significantly alter the existing water quality of the rivers of Texas. The total maximum projected water usage for lignite development will be only about 1.6 percent of the cumulative average flow of the rivers possibly affected. This loss of about 1.6 percent of the average total flow will not measurably affect the aquatic biota during average conditions.

The above comparison does not give an accurate picture of the possible effects on each river basin. The individual basins will vary greatly in the percentage of average flow used by lignite development by the year 2000. However, it is improbable that water use associated with lignite development would be concentrated in one or two river basins. The effects of lignite-related water usage on the biota of individual basins is beyond the scope of this study; rather, the cumulative effects on the entire region are discussed in general terms.

During years of normal river flow, there should be no significant changes in the overall freshwater aquatic biota caused by depletion of the flows due to lignite development. This conclusion is based on the small percentage of the average flow predicted to be used by lignite development when compared with the recorded low flows of the various rivers. Lignite development will not cause drought condition low flows. It will, however, increase the frequency of low flows, as will any consumptive use or natural drought. During droughts, such as those experienced in the early 1950's, the aquatic biota suffer. However, they survive in various reservoirs, natural springs, and other areas from which the total basin of each river is repopulated. It is unlikely that lignite-related development per se will cause reductions in water quantity that will destroy significant populations of aquatic biota in the major rivers.

In some of the river basins, lignite-related water use when added to other water usage may create stressful situations much more often than would occur otherwise. These synergistic effects may need further clarification in order to ascertain the possible effects of the total water usage in individual river systems.

The effects of lignite mining and runoff from indirect development on the aquatic biota of the many small perennial streams that will be disturbed are difficult to predict. As is stated in previous sections on water quality, siltation and lowered dissolved oxygen levels in the streams may occur in some areas until adequate control measures can be instigated. If all local, state, and federal regulations are followed, there should be little long-term degradation of the small streams in the lignite region. The streams directly affected by mining will repopulate following reclamation. They should repopulate to conditions somewhat similar to those before mining unless the streams are channelized. Since the biota of these streams have generally little significance in the region's overall aquatic ecosystem, changes are unlikely to be regionally significant. These streams are important to wildlife that depend upon them for water and for aquatic food organisms; however, lignite development is not expected to obliterate them permanently. Lignite development will destroy sections of streams for the duration of mining and then replace them during reclamation. This should be sufficient to insure their continued use by wildlife as it repopulates the reclaimed mine areas and areas downstream of the affected stream segments.

The problem of decreased freshwater inflows to Texas' highly productive estuaries may be slightly aggravated by lignite-related water usage. The amount and timing of freshwater inflows are thought to be of prime importance to various important estuarine animal species. These inflows are currently controlled by the dams on most Texas rivers, except during floods. The relatively small amount of water predicted to be consumed by lignite development should not decrease the freshwater inflows to the estuaries enough to significantly affect the animal populations. If necessary, water consumption can be compensated by managing dam releases so that the estuaries receive the same amounts of water at the proper time.

The actual significance of the amount of fresh water that flows into the estuaries and its timing with regard to its effects on the estuarine biota is presently unclear. Several studies of the inflow needs of Texas estuaries are either currently being conducted or will begin shortly under the auspices of the U.S. Fish and Wildlife Service. Past studies of Texas bays and estuaries have failed to find the answers to the questions surrounding the freshwater inflow requirements of estuarine organisms. These current and future studies should be able to ascertain the freshwater inflow needs of the estuarine organisms. They should also provide water management recommendations for the protection of the estuarine biota. They will undoubtedly provide further insight into the possible long-term effects of lignite related water usage.

The cumulative effects of thermal loading from lignite-fired power generating facilities is another possible area of regulatory concern. The changes in aquatic systems due to heated effluents have been studied extensively in Texas for decades. Under present regulations and practices, thermal discharges to freshwater bodies have not been shown to have a significantly adverse effect on the aquatic biota of their receiving waters. Of course there are changes; however, they do not damage the biota of the receiving waters. In most cases the heated water accelerates growth in sport fish. It also tends to prevent or at least postpone the decline in sport fish populatons usually experienced in Texas lakes after eight to ten years. The exact reasons for this are presently being studied in several Central and East Texas reservoirs.

During the hottest period of the year (July - August), fish migrate to cooler portions of cooling lakes or ponds. In this way they escape adverse effects from heated effluents often in excess of 40°C. Most fish in cooling ponds have very broad tolerances to temperature fluctuations. This decreases the chances of their being adversely affected. During the winter the fish migrate to the warm discharge area. Fishing is usually excellent in the heated effluent at this time. Only in cooling ponds or lakes where there are no areas to which the fish can escape the extremely hot water will adverse impacts be seen. For those reasons, thermal effluents have not been a serious threat to the freshwater aquatic biota of Texas.

5.0 MAJOR ISSUES AND PROBLEMS SURROUNDING LIGNITE DEVELOPMENT

The following discussion attempts to define the main areas of controversy surrounding the development of lignite. Some uncertainty has arisen lately in the literature over the distinction between "problems" and "issues." In this study, "problems" are considered to be the potential adverse impacts discussed in Chapter 4. "Issues" arise over the choice of solutions to these problems. This chapter considers ways that present policy patterns create problem-solving difficulties, which have not yet been resolved. In many instances, conflicts between national and regional goals create the difficulty. In others there are impediments to changing old policies or implementing new ones. All of the issues that have been raised to date are not discussed here. Only issues with a large potential influence on the environment or those involving major federal policies have been included.

The issues themselves have been placed in two groups. The first group contains issues affecting the scale, location, and timing of lignite development. Some of these do not arise directly from environmental considerations, but are included because they affect the overall pattern of development. It is this pattern which ultimately determines what the cumulative environmental impact will be. The second group of issues centers on problems of mitigating or avoiding those impacts that occur. These issues largely center on the adequacy of existing institutional machinery to handle the expected problems.

Preceding page blank

5.1 Issues Affecting the Scale, Location, and Timing of Lignite Development

5.1.1 Water Availability

As was shown in Chapter 4, there is insufficient unappropriated water available in Texas to accommodate lignite development in the southern and central portions of the lignite belt. This condition will tend to promote lignite development in East Texas. Lignite is also of higher quality in this area and the climate is most favorable to reclamation. Since generally the available "new" water rights are inferior to many prior rights, power plants, gasification facilities, and mines outside East Texas will probably obtain their water needs by purchase on contract from large reservoirs. Even contract water, however, is in short supply, particularly in the Colorado and Trinity River basins. Consequently, lignite interests will have to purchase other existing water rights.[1] Agriculture, which presently uses an estimated 72% of the water consumed in Texas (TE -310) is probably the most readily available source of water rights through purchase. Rising costs of contract irrigation water (presently between $20 and $30 per acre-foot) will contribute to the shift of contract water from agricultural to industrial use, as farmers find themselves unable to compete for the resource.

Like many western states, Texas operates on a prior appropriation water right system, appropriating water for beneficial use on a first-in-time, first-in-right basis. There is presently no updated summary of active appropriations. The Water Rights Commission is undertaking a massive adjudication program. This process may "find" substantial amounts of unused water, but will probably not be complete for many years. In addition, the water rights system in Texas has essentially promoted inefficient water use. The owner of a water right must have actually used the water at some time, but may not always continue to use all of the appropriation. Thus, there may be additional supplies of water that are not being used. At least a partial solution to the potential water shortage and its impact on agriculture could be found if this "found" water could be allocated according to a priority system designed to further a balanced statewide economy.

---

[1] Utilities have the right to condemn water, but the extent of this authority has never been tested (UN-085).

The basis for such a priority system exists, in the Wagstaff Act of 1931 (U.C.T.A., Water Law, Section 5.024), which sets up a system of dealing with competing demands for the same water. However, these priorities[1] are currently applied only at first certification of water rights, and then only if there is competition. All appropriations are made on a case-by-case basis. No mechanism exists for continuing evaluation of water uses, or for allocating water saved by conservation according to a pre-arranged plan.

State legislation would be required to enforce conservation and to establish a priority system of allocation. Substantial opposition would be encountered to such an effort; water is regarded as a property right in Texas, and users presently acquire title to their appropriation by limitation after three years of use (V.T.C.A., Water Code, Section 5.029).

Another potential means of "finding" more water in Texas might be through coordinated management of surface and ground waters, an approach long advocated by the Water Development Board (TE-310).[1] As water development increases and its hydrological impacts become more complex, more and more time is required for planning. It is therefore important to begin such a process quickly. However, revisions in state law would be necessary to establish authority for coordinated surface/subsurface management. It is considered doubtful if such legislation could pass. According to both popular attitudes and current legal stance, water in Texas is considered a common-law property right. The farmers and ranchers of central and southern Texas are presently using ground water rapidly enough to deplete long-term aquifer storage capacity. This influential group will oppose initiatives that would cut back their supply.

---

[1] Priorities in appropriation, in decreasing order, are: domestic and municipal use, including livestock watering; industrial use, including non-hydroelectric power; irrigation; mining; hydroelectric power; navigation; recreation and pleasure; other uses.

Based on existing state water policy alone, the outlook for systematic, basinwide planning, conservation, and allocation of water supply appears unpromising. Countervailing doctrines are firmly entrenched in state water law and reinforced by practice. Current federal efforts to establish an updated, uniform water policy could conceivably break the impasse by mandating state legislative reform. A thorough analysis of the implications for Texas of the policy options developed by the Water Resources Council (Federal Register, July 15, 1977, Part VI) is both premature and outside the scope of this study. However, it is clear that their emphasis on modern, hydrologically sound planning could clear the way at the state level for substantial improvements in water rights management. Such policy recommendations, however, will have to overcome strong objections from the states. On the other hand, several of the Water Resources Council policy options could conceivably make matters worse, depending on their implementation. Particularly, any attempt to condemn water rights and reallocate them will need to be coordinated with a conservation program. Otherwise, substantial economic damage could be done in water-short areas by "borrowing from Peter to pay Paul." Water pricing as a means to promote conservation will almost certainly contribute to the movement of water from agriculture to industry.

---

[1] The three Texas water agencies - Water Rights Commission, Water Development Board, and Water Quality Board - have been merged as of September 1, 1977. However, their functions will remain largely distinct, and no major policy changes accompany the merger.

5.1.2 Consumptive Water Use

The ultimate impact of the growth in water demand for lignite-fired power production will be expressed as cumulative reductions in flow. As explained in Chapter 4, a much more sophisticated analysis than was possible in this study would be needed to determine what, in Texas' highly variable, highly regulated river systems, this ultimate reduction might be. A preliminary analysis suggests that depletion sufficient to adversely affect freshwater inflow to Texas' productive bays and estuaries is not likely to occur as a result of lignite development alone. Lignite will contribute, however, to a substantial total growth in water demand which can have local effects on the instream flows required to sustain aquatic ecosystems.

The Texas Water Rights Commission advised by the Water Development Board and the Texas Department of Parks and Wildlife can protect instream flows through its permitting system. However, as is the case with most aspects of water regulation in Texas, everything is done on a case-by-case basis.[1] There is no basis for coordinated planning. More significantly, it appears that much of the local impact on surface water flow and quality can theoretically be controlled by operating existing on-stream reservoirs. However, reservoir operation is set by state water rights which restricts alternatives considerably (TE-310). Some sort of reservation for instream flow protection might be required. Considerable study would be necessary before a technically effective plan could be devised and a strategy proposed for overcoming legal and institutional constraints.

---

[1] Note that the priorities in the old Wagstaff Act include no explicit reference to instream flow needs. Included under "other beneficial uses," they rank eighth and last.

Another mode of combatting depletion is to reduce consumptive use. A major component of the consumptive use of water arising from lignite-fired power generation derives from cooling. Most utilities either use off-stream impoundments for evaporative cooling or build wet cooling towers. As discussed in Chapter 4, cooling towers are preferable only in the extreme southern part of the lignite belt, where evaporation rates are high. Lakes and ponds are equivalent or superior to towers in the more humid central and east parts of the State.

Because of evaporative losses, towers and ponds may consume 30 to 100 percent more water than cooling lakes, depending on locality. The staff of the Water Development Board, charged with conserving the state's resource, considers that "from an overall water resources management standpoint -- single-purpose cooling reservoirs should be used only when absolutely necessary." Multi-purpose reservoirs would be the method of choice (HO-389). From the standpoint of state water management, cooling towers are the least acceptable mode of using surface water.

Substantial impediments to such a strategy exist, however. The 316a variance procedure required by the Water Pollution Control Act Amendments of 1972, (PL 92-500), along with various practical drawbacks, make reservoir use unattractive.

In 1976, the existing EPA guidelines regarding the 316a variance were overturned in the Fourth Circuit Court of Appeals, on grounds that they did not adequately consider water supply. Draft guidelines are now out, but have not been adopted. In the interim, EPA Region VI has received only one application for a variance in Texas, and has no firm policy regarding the kinds of data required. The 316a process requires proof that the proposed thermal discharge will not cause ecological damage. Generally speaking, it is time-consuming and difficult. The uncertainties surrounding its future implementation also act as very strong incentives to avoid locations possibly requiring a variance. Multi-purpose reservoirs fall into this category. In addition, the practical difficulties of siting on premium lakeshore land, as well as reconciling such locations with demand patterns and fuel sources, may be even more important drawbacks.

Cooling ponds, on the other hand, require no 316a variance, by statutory definition. A cooling pond, as opposed to a cooling lake, is exempt from 316a, but the distinction is not always clear. An impoundment on a navigable stream which discharges downstream is clearly a lake according to the law. And an impoundment on a non-navigable portion of a drainage, with no discharge, is clearly a pond. However, intermediate cases abound where intermittent streams are involved. These are addressed in a more or less discretionary fashion, according to informal guidelines and policies within the regional EPA office.

In summary, there is substantial incentive for utilities to build smaller headwater cooling ponds or cooling towers, even though these technologies are the most detrimental to State and Federal water conservation objectives. The 316a variance procedure, while a contributing factor , is probably less significant than economic considerations in favoring the use of single-purpose cooling reservoirs. Without 316a, however, more cooling lakes, with evaporative losses as much as 20% below cooling ponds, might be built.

5.1.3 Water Use Conflicts

A variety of other conflicts have arisen over the development of water for lignite. These are not issues of such statewide significance as those surrounding appropriations or coordinated planning. However, they do constitute a potential for delay in the overall development picture.

One such conflict involves the replacement of habitat lost by reservoir development with other lands managed for wildlife. The U.S. Fish and Wildlife Service requires such "mitigation"[1] before approving dredging permits under Section 404 of the Water Pollution Control Act Amendments of 1972. This policy has sparked a controversy in regard to the proposed Choke Canyon Reservoir which has been sent to the Secretary of the Interior for resolution. If the Secretary rules that mitigation should be part of this project, a precedent will be set for other water developments. The major disagreement revolves around the issue of who should bear the cost of acquiring and managing the mitigation lands.

A different kind of conflict has arisen over two proposed reservoirs underlain by substantial lignite reserves. One of these (Tennessee Colony) can be relocated, although some lignite would still be affected. There is also some concern over phasing reservoir construction with planned mining. In the case of the other (Millican), the Corps has recommended against construction, perhaps in part because of an overall move away from the construction of new reservoirs (Water Development Board staff, pers. comm.). Other projects that have been authorized, but not yet budgeted, include a navigation canal permitting barge traffic up the Trinity River to Dallas, and another reservoir on the Navasota River. Locally, lignite mining would interfere with these plans. It is worth noting, however, that the provisions of the new Federal Surface Mining Act, PL 95-87 have added to the uncertainty of mining in the bed of the Trinity and other rivers, which might be considered an area unsuitable for mining because of the threat of flood.

---

[1] Authority for this policy comes from Section 662 of the Fish and Wildlife Coordination Act (P.L. 85-624).

5.1.4 Air Quality Maintenance

The recent passage of the Clean Air Act Amendments of 1977 has greatly changed the regulatory climate in Texas. The policies set in that law have largely pre-empted certain decisions previously made at the state level, and much of the previous case-by-case flexibility will be lost in consequence. The net result of the new Federal policies appears likely to increase the use of lignite greatly, accompanied by a much more scattered pattern of lignite-related industrial development than would otherwise have taken place. These consequences arise primarily from changes in three areas: New Source Standards of Performance (Section 109), Prevention of Significant Deterioration (Section 127), and Nonattainment Areas (Section 129).

5.1.4.1 New Source Standards of Performance

The greatest impact of the new Act on the Texas lignite industry will probably arise from its requirement that all new coal or lignite-burning sources use "best available control technology" to reduce emissions. Low-sulfur Western coal could meet previous NSPS without scrubbers, while lignite could not. Removal of this significant economic advantage makes the cheaper, local lignite much more attractive relative to imported coal. BACT now applies to SO_2 and particulates, but new standards for NO_x, hydrocarbons, and carbon monoxide are required under the Act. Further study will be needed to determine what differences these new standards may make in the economics of using lignite versus Western coal. As long as both fuels require essentially similar control hardware or modes of boiler operation, however, the initial advantage afforded to lignite by the universal requirement for BACT will probably continue. The Act also affords the opportunity to regulate other pollutants, such as arsenic and radionuclides, although it does not specifically require such regulations. A study of the relative concentration of such substances in Texas lignite and other coals, along with the availability and cost of technologies to control them, might reveal more significant differences. If future emission standards change the relative economics of lignite versus imported coal, the net environmental impact of lignite development will be directly affected.

5.1.4.2 Prevention of Significant Deterioration

One of the major conclusions of the analysis in Section 4.4 is that a potential conflict exists between PSD regulations and large-scale lignite development. The development forecast set out in Chapter 2 stated that as many as thirty (30) 1500 MWe lignite-fired power plants may be needed by 2000. The potential for conflict becomes obvious when an attempt is made to locate new power plants near the lignite deposits.

For analysis, it will be assumed that new facilities cannot be closer than 30 miles to another lignite-fired power station. Under the worst atmospheric conditions, no significant plume interaction is expected between two worst-case, 1500 MWe plants separated by 30 miles or more. In reality, 1500 MWe plants can be constructed much closer without the violation of the PSD standard.

Figure 5.1-1 shows graphically an attempt to locate plants as near the lignite deposits as possible without significant plume interaction. Lettered sites are existing or planned lignite-fired plants; the numbered sites are the hypothetical locations. In the southwestern portion of the belt, sites 1 and 2 appear to present no problems with respect to plume interaction. However, due to reclamation costs, scarcity of water, poor quality of lignite, and relatively low demand for electricity in nearby urban centers, the development of more than two additional 1500 MWe plants appears unlikely.

Continuing to the north, site 3 presents no problems. However, that lignite deposit is "potential," and the site cannot be depended upon to be economically attractive. Site 4 is in the Camp Swift area of Bastrop County. With the Austin and San Antonio markets nearby, it appears to be a good site. Site 5 will not present problems with plume interactions and it will probably be developed eventually.

Sites 6 and 7 in northeast Texas are both located off the lignite belt a few miles to maximize development in that area (near Dallas). Site 8 will not present plume interaction problems. Sites 9 and 10 represent an attempt to locate as many plants as possible in that area without plume interaction. However, both are located on "potential" deposits and cannot be counted on with a high degree of confidence.

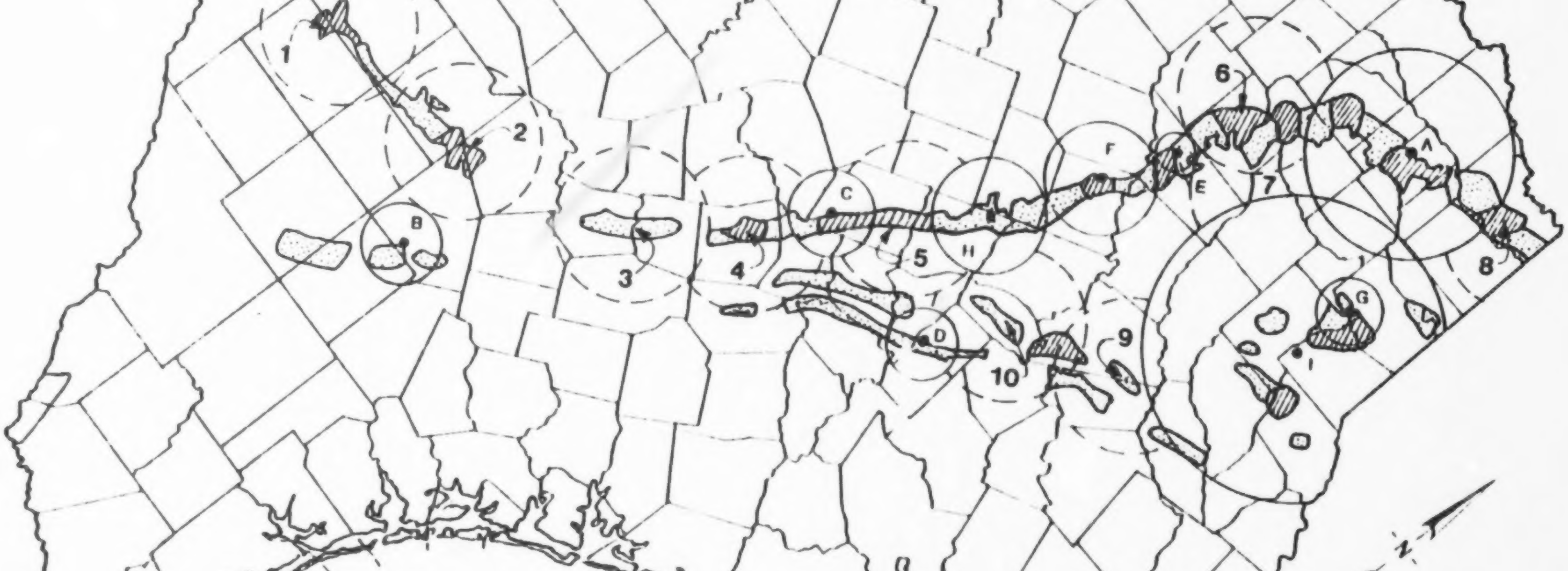

1
2
3
4
5
6
7
8
9
10
A
B
C
D
E
F
G
H
I
N
POTENTIAL LIGNITE DEPOSITS
PRINCIPAL LIGNITE DEPOSITS
ZONE OF POSSIBLE PLUME INTERACTION
SCALE IN MILES
0 20 50 100
A MONTICELLO # 1,2,3
B SAN MIGUEL #1,2
C SANDOW # 1,2,3,4
D GIBBONS CREEK #1,2
E FOREST GROVE #1
F BIG BROWN
G SOUTH HALLSVILLE
H TWIN OAK #1,2
I MARTIN LAKE # 1,2,3,4.
1 TO 10 ARE HYPOTHETICAL

FIGURE 5.1-1

HYPOTHETICAL DISTRIBUTION OF EXISTING, PLANNED, AND FUTURE LIGNITE-FIRED UNITS AT THE MINE-MOUTH

In this simple allocation exercise, only ten plants were located. More could probably be fit in along the lignite belt with more accurate mapping. However, some of the locations are not in the best areas for energy development when reclamation and demand are considered.

Obviously, more plants can be practically located near the lignite deposits by either utilizing technology changes discussed earlier or by increasing the degree of cumulative air quality impacts. Another way to allocate more plants is to assume that the lignite will not have to be utilized at the mines. Thirty miles is as far as lignite can be economically moved under current conditions. However, this may change as energy becomes more scarce.

If transportation becomes less of a constraint, plants will probably be constructed away from the lignite belt in areas where no significant plume interaction can be expected. This may also place the power plants nearer the major consuming areas in southeast Texas (Houston to Beaumont) and along a line from Sherman to San Antonio. However, they may eventually cause problems with air quality in these metropolitan areas.

In summary, the concerns raised and resolutions considered in this allocation exercise are not a forecast of certainties. However, these potential problems and conflicts do indicate that cumulative air quality impacts accompanying intensive lignite utilization cannot be dismissed as improbable. Any policy changes which affect the context in which such problems are generated or conflicts resolved may have a direct bearing on the likelihood of air quality degradation. The changes in the PSD standard of the 1977 Amendments is an excellent example of such a policy initiative.

Eventually, it may be considered desirable to redesignate parts of the lignite belt Class III, thus increasing the number of plants which can be sited economically. Some delay between the need and the actual redesignation may be expected because of the complexities of the process. A study of the effect of redesignating various parts of the lignite belt, in different time frames, could provide valuable information for planning.

The option also exists to redesignate certain areas Class I, which could further complicate the siting problem. Areas near the lignite belt for which a Class I designation might be appropriate include.

- The Big Thicket
- The several National Wildlife Refuges along the Gulf Coast
- The Upper Guadalupe River, proposed for inclusion in the National Wild and Scenic River System

Additional study of the impacts such redesignations might have on siting in the adjacent Class II areas would also be a useful planning input. The new Amendments require the administrator of all Federally managed lands to inventory them and make recommendations concerning redesignation to Congress, after consultation with the state. A necessary part of this analysis will be an examination of its impacts on siting.

5.1.4.3 New Sources in Nonattainment Areas

Virtually the entire industrialized portion of the Texas Gulf Coast is designated as a nonattainment area for TSP and photochemical oxidants, but not for SO_2. Consequently, the very strict provisions for siting new sources contained in the

Amendments will not prove very restrictive for new combustion sources. However, lignite gasifiers, and the industries using synthesis gas as feed, contribute to hydrocarbon and hence to oxidant levels through emissions and fugitive losses. Such facilities can only be sited in these nonattainment areas (NAA's) if a sufficient reduction in hydrocarbon and oxidant emissions occurs through other measures to compensate for the new sources contributions. The net result must be "reasonable further progress" toward meeting the deadline for compliance,[1] as determined by the Administrator of EPA.

In the Gulf Coast NAA's, excessive oxidant and CO levels arise from two principal sources: petroleum and petrochemical industries and vehicular emissions. Thus, one way to preserve the option to site new sources there is to institute controls on traffic and emissions from vehicles. To the extent that "reasonable further progress" cannot be made in this way, emission reductions offsetting those of proposed new sources will have to come from industry. Fugitive losses - a large part of industrial hydrocarbon emissions contributing to oxidant formation - are very costly and difficult to control. Thus it seems possible that some new sources would be located outside the coastal NAA's, in the inland Class II regions.

The trend toward shifting from methane-based feedstocks to synthesis gas may enhance the likelihood of at least some secondary industry locating near gasification plants built in the lignite belt. Further study of industry economics would be necessary to support more than a speculation. However, there is substantial current interest in lignite gasification for feedstock use. If a corresponding shift takes place in process design to use the gasified lignite, new plants may be needed which would be difficult to site in the NAA's. These might be economically built, in some cases, near the feedstock source. If such a trend were to materialize, it could exacerbate the problem of complying with PSD on siting power plants in the lignite belt. It would also bring with it economic and social impacts, and contribute to regional water quality and quantity problems. Because of this potential, a more rigorous investigation is strongly suggested.

---

[1] The latest date for attaining NAAQS for photochemical oxidants, according to the new law, is December 1987. Commercial gasification plants in Texas may begin operating by the mid eighties (See Section 5.1.5).

5.1.4.4 Federal/State Conflicts

The Texas Air Control Board is empowered by law to adopt and enforce its own regulations, including new source performance standards. New sources must obtain a construction permit from TACB, before construction can begin. Permit criteria include prevention of significant deterioration, maintaining Federal and state standards, and land use considerations. (Texas Air Control Board Regulation VI.) However, the Board is permitted a good deal of flexibility in applying its rules and regulations.

The Texas Clean Air Act of 1967 (Tex. Rev. Civ. Stat. Ann. art.4477-5 § 3.10(a), 1967) states that:

> a rule or regulation or any amendment thereof adopted by the TACB may differ in its terms and provisions as between particular conditions, as between particular sources and as between particular areas of the state. In adopting rules and regulations the Board shall give due recognition to the fact that the quantity or characteristics of air contaminants or the duration of their presence in the atmosphere

> which may cause a need for air control in one area of the state may not cause need for air control in another area of the state, and the Board shall take into consideration in this connection all factors found by it to be proper and just, including topography and prevailing wind directions and velocities, and the fact that a rule or regulation and the degrees of conformance therewith which may be proper for an essentially residential area of the state may not be proper for either a highly developed industrial area or a relatively unpopulated area of the state.

The Act also requires TACB to consider the "character and degree of injury to, or interference with the health and physical property of the people" in setting "reasonable" emission levels. Technical practicability, cost of emission control, and the source's social and economic value must also be considered. Variances are available where economic hardship might otherwise result.

TACB has always tried to avoid restricting industrial growth, but requires it to conform to an overall goal of protecting the "normal health, general welfare and physical property of the people." A hallmark of this approach has been flexibility - the ability to balance economic and environmental needs on a case-by-case basis.

The new Clean Air Act Amendments of 1977 will pre-empt much of this flexibility. The revised NSPS, with their requirement for BACT, remove the option of regulating primarily on the basis of resulting ambient concentrations. The Federal emphasis on emission control also restricts dispersion-based strategies such as tall stacks. Operating at reduced capacity is similarly limited. Some flexibility remains in the provision for using site-specific information in PSD permit applications, and the use of innovative control technology. However, the old approach of tailoring control to circumstance is no longer possible. In particular, "economic reasonableness" may no longer be used as a criterion for determing the choice of control technology.

The new amendments also expand and cement the Federal role in enforcement. The TACB has in the past expressed the view that EPA has assumed primary regulatory responsibility, through the NAAQS, which rightly belongs with the state (TACB, 1975a, as cited by WH-124). The new Admendments add to this the revised New Source Performance Standards, PSD increments and provide for standards and increments for pollutants not now so regulated. Especially contrary to the state view is the quantitative definition of "significant deterioration" by Federal statute for the entire Nation. TACB has stated (TACB, 1975a as cited by WH-124) that since the NAAQS already protect health and welfare, criteria for "significance" may safely be left to the states. A proper role for EPA would rather be restricted to areas with an obvious national perspective: NSPS, new vehicle emission standards, ambient air quality and standards for hazardous substances. Responsibility for air quality control should rest with the states, in the view of TACB.

Finally, it is widely felt in Texas that zoning the state with respect to PSD will restrict economic growth and impose unwanted land use controls. Federal policies regarding both PSD and permitting on non-attainment areas are seen as "growth or no-growth" issues. The results of this study do not indicate quite such a basic conflict, but it is clear that these Federal policies can have widespread secondary impacts. At least some new industrial activity will tend to be forced out of NAA's, where economic considerations would normally place it. But PSD will add to the cost of buildings elsewhere - and perhaps restrict the choice of site. Already, PSD increments near some major industrial centers are almost fully taken up. Thus, while growth is still possible, it will cost more; this will have some degree of impact on the state's economy.

Another kind of secondary impact arises from the tendency of PSD to scatter industrial development rather than permitting it to cluster. Thus, the local social and economic impacts of growth in rural areas are multiplied. Supplying public services in an increased number of growth communities is a state and local burden, which this Federal policy tends to increase. Land-use impacts, as well as less tangible influences on lifestyle, are also spread more widely by PSD policy.

5.1.5 Issues Related to Lignite Gasification

Texas and Louisiana use more natural gas in industry than any other states. Thus the Federal government's efforts to shift fuel use from gas and oil to coal can have disproportionately large impacts on the Gulf Coast.

5.1.5.1 Factors Influencing the Development of Lignite Gasification

Synthetic gas from coal or lignite appears likely to play an important role in this transition. Gasification can produce two kinds of product, used in different ways. A low- or medium-Btu fuel gas can be used to generate process steam or heat, or to generate power. A medium-Btu gas, enriched in hydrogen and carbon monoxide, can also be made. This "synthesis gas" can be used as a feedstock for petrochemical products. It is particularly well suited for making ammonia and methanol, now produced from natural gas. These two products alone made up 25% of the capacity of the Texas chemical industry in 1975.

As discussed in Chapter Two, large users of natural gas as a boiler fuel will probably find it most economical to switch to direct combustion of coal or lignite. The cost of adding a gasification step outweighs the benefits of continuing to use existing gas-fired equipment. Peaking units are an exception. Combined-cycle applications and co-generation also appear promising. However, gas of less than 300 Btu's per cubic foot cannot be burned in existing boilers without modifying them. Similarly, process and equipment modifications are needed if methane is replaced by a H_2/CO synthesis gas as a feedstock, except for the manufacture of ammonia and methanol.

Until recently, the cost of these changes and perceived uncertainties in capital supply appeared to limit gasification's future (WH-124). Lack of experience with using gasified coal or lignite in petrochemical processes was a further technological drawback. However, recent State and Federal policy changes have now made the natural gas availability picture uncertain enough to override these problems.

A number of pilot studies are underway, and commercial projects are also being seriously planned. Texas A&M's Center for Energy and Mineral Resources, with funding from several large chemical producers, is studying Nazi coal conversion processes. During the war, processes were developed to convert German brown coal into a large number of products. Texas lignite closely resembles brown coal, and could possibly be used in these processes. An ERDA-funded pilot study in Cedar Bayou, near Houston, is investigating markets for synthesis gas from lignite. In addition, a large oil company is investigating a medium-Btu lignite gasification plant near Longview to ship synthesis gas to the coast. The Texas Governor's Energy Advisory Council has adopted a formal policy favoring "federal support for synthetic fuels development and prototype demonstration in the form of loan guarantees . . .".

The major factors behind this trend are uncertainties of supply and proposed economic penalties for continued use of natural gas in industry. Price controls have a strong influence on gas supply. The consensus of economists and energy specialists is that price controls hold back production (FI-159; MC-325). It is thought that price ceilings do not reflect actual replacement costs. Consequently, reserve addition rates will fail to arrest declines in production. The result will be continued shortages and higher prices, making gasification more competitive. Even without price controls, the heavy economic penalties proposed for continued use of natural gas favor the use of gasified coal or lignite. These tax penalties do not distinguish between flexible (fuel) and non-flexible (feedstock) uses of gas. Thus gasification has become attractive to a broad spectrum of users.

The shift from gas as a fuel for new boilers is already under way, due largely to rising costs. This economic trend is reinforced by policies of the Texas Public Utilities Commission, and the Texas Railroad Commission. New boilers are prohibited from using natural gas, and overall gas use as a boiler fuel must decline 10% by 1981, and 25% by 1985. However, 70% of the gas presently consumed in Texas is used in boilers, which will eventually have to be phased out.

Under both Federal and state gas curtailment schedules, industrial and utility boiler fuel users are in the lowest priority (i.e., first to be curtailed in periods of supply shortage). Other industrial uses are the next lowest priority with essential residential and small commercial users being the highest priority. As curtailments on both systems increase, it is likely that this mechanism alone will force fuel conversion and provide incentives for gasification.

Continuing shortfalls of gas supply are expected to lead to a greater degree of Federal end-use allocation. Gas supplies allocated to high-priority residential users outside the Gulf Coast can only come from gas-dependent industry in the producer states. Since 70% of the gas consumed in Texas is burned in boilers, the economic penalties of such a policy are likely to be very high. The essence of the State-Federal conflict over how to manage the shortage lies in the concept of allocation by user type *versus* allocation by pricing. The Federal view generally favors allocation by priority on a nationwide scale. Texas policymakers would rather have a system that relies on the market mechanism to set supply and demand with a curtailment schedule based on priorities for periodic shortages only.

A factor which could constrain the actual development of a gasification industry is Federal and State clean air policy. Many of the industrial users identified as comprising the most probable demand for gasified coal or lignite are located along the Gulf Coast, in areas presently exceeding National Ambient Air Quality Standards for hydrocarbons and particulates. Gasifiers emit hydrocarbons both as process emissions and as fugitive losses, and consequently would probably come under the tradeoff policy. Thus, it may prove impractical to site gasification plants near demand centers. Further study would show whether this limitation would curtail opportunities for co-generation or other multiple applications. However, burning coal or lignite in a non-attainment area for particulates may not be possible. Clean air policy thus has a countering influence: gasified coal or lignite emits few particulates. In sum, *it appears likely that both the location of gasifiers, and the demand for them to supply clean fuels, will be strongly affected by Federal air quality policies*.

5.1.5.2 Probable Future of Gasification in Texas

The combination of factors outlined above appears likely, if unchanged, to bring about commercial gasification in Texas by the mid-1980's. The principal markets for synthetic gas appear likely to be:

- Peaking capacity in large generating systems (if not exempted from tax penalties, or curtailment)
- Process steam and heat serving groups of small-capacity industrial users
- New petrochemical plants designed to use H_2/CO feedstock

Industrial parks might form a special category of users. Especially where manmade particulate levels are high, or in areas where PSD increments are nearly used up, gas may be the only feasible fuel. Certain areas adjacent to the industrialized parts of the Gulf Coast may fall into this category. Use of a clean-burning synthetic medium-Btu gas, which could be piped cost-effectively as far as 150 miles, might allow more industries to locate close together. Industrial parks present opportunities for more efficient cooperative energy use, which would thus be preserved.

As discussed in Chapter Two, Texas lignite has characteristics which will probably allow it to compete favorably with bituminous coal as gasifier feed. Deep-basin lignites can probably only be developed economically by in situ gasification. However, at least the first gasifiers built in the State are likely to be more conventional above-ground facilities.

5.1.6 Issues Related to Mining

Issues related to mining ultimately express themselves in terms of the relative proportion of Texas' solid fuel needs which will be met by lignite, as opposed to imported coal. In turn, this balance turns on relative cost and timely availability. Two kinds of issues may be identified: those affecting the ownership of surface-mineable coal and lignite, and those arising from the permitting procedure required by new Surface Mining Control and Reclamation Act of 1977 (PL 95-87). Especially in the latter set of issues, there are substantial uncertainties which may emerge as "sleeper" issues in the near-term future.

5.1.6.1 Assignment of Ownership

Wherever surface and mineral rights are held separately, there is controversy over the assignment of rights to surface-mineable mineral deposits. In Texas, rights to lignite have been thought to be held by owners of "oil, gas, and other minerals" leases. Mineral rights are historically dominant over surface rights, and the Texas Constitution has been construed as supporting this position.[1] Many such leases, however, predate the era of widespread surface mining, giving rise to ambiguity as to the actual intent of the parties involved.

Texas lacks a consistent legislative policy on this question, and all disputes must presently be settled in the courts. Rulings in relevant cases have gone both ways -- in favor of the holder of the surface and of the owner of the mineral rights. Considerable contradiction is apparent between the specific reasoning used in these rulings. In general, however, the courts have tended to favor the party with the fewest alternatives. Thus, surface owners have been successful where the developer of the mineral estate could employ other "reasonable" means of exploiting it. Where no other options were available, mineral developers have tended to prevail. Surface mining presents special difficulties. At least during the mining operation itself, the mineral owner may have no alternative means of extraction. At the same time, the surface owner has no alternative method to use his rights.

---

[1] Southwestern Law J., 1976, as cited in WH-124.

Three recent decisions[1] have been based on the theory that the surface owner, in severing the mineral estate, could not have intended strip mining as a means of development. The courts see surface mining as effectively precluding surface use. Opponents of this reasoning claim that the surface is reclaimable. Therefore, the surface owner can justly claim only compensation for a fair market rental for the affected land for the time it is disturbed, and for any loss in its value after reclamation is complete.

These three cases constitute a strong trend toward assigning surface mineable lignite to the surface estate in legal instruments where no specific mention of it is made. However, they do not establish a clear policy. Section 510(b) (6) of the Federal Surface Mining Act (PL 95-87) requires that surface-subsurface relationships be determined by state law. The Act further specifies that "nothing in this Act shall be construed to authorize the regulatory authority to adjudicate property rights disputes." Under these circumstances, it will likely be the policy of the Texas Railroad Commission -- when authorized to administer the new law -- to refer disputes regarding permit applications made on the basis of "oil, gas and other mineral" leases to the courts for adjudication. If such disputes are common, the timely availability of lignite could be threatened (Texas Railroad Commission Staff, personal communication).

---

[1] Acker v. Guinn; Williford v. Spies; Reed v. Wylie.

There has been some concern over the potential for lease renegotiation which might arise from this situation. On a large scale, such a round of new lease agreements could result in increased prices for lignite, affecting its already somewhat tenuous market position. Should coal companies holding mineral rights decide to protect their interests by re-uniting the severed estates, the most favorable route would be through purchase of surface rights. Otherwise the same disputes crop up again over the question of royalties. The surface owner would then be in a position to hold out for a high price, reflecting the value of the lignite. This could result in costly delays and possibly injure the market position of lignite. The lignite industry in Texas is already marginal in some respects, and producers have elected to take the stand that lignite goes with a lease for "oil, gas and other minerals." If the only way a surface owner can contest a mineral leaseholder's right to surface mine is to go to court over a permit application, there is little likelihood that large-scale lease renegotiation will take place. The extent of split property ownership in Texas is not now known. It would be useful to determine both the number of such cases and the proportion of them that will need to be renewed within 10 to 20 years.

5.1.6.2 Obtaining a Mining Permit Under PL 95-87

The first issue arising over the new federal permitting process is whether the state will qualify to administer the program prior to the 18-month deadline written into the law. The Texas legislature meets every two years; its next session begins in January of 1979. In anticipation of federal legislation, however, it passed a reclamation law in 1975 which was expressly designed to permit the state to assume jurisdiction over the federal program then under consideration. The state law expressly grants authority to the Texas Railroad Commission (RRC) "on passage of any federal surface mining legislation. . . to take the steps necessary to establish the exclusive jurisdiction of this state over the regulation of surface mining and reclamation operations . . ." including making recommendations for remedial legislation.

Despite the conceptual similarity of the state and federal laws, some specific differences exist which will have to be resolved before the RRC can propose an acceptable state program. Most differences can be handled through administrative action, but additional state legislation may be needed to establish:

- A requirement for revocation of a permit if mining has not commenced within three years
- RRC authority to require permit revisions during the permit period
- A conflict of interest clause forbidding RRC employees from having a financial interest in coal or lignite mining
- Provisions for citizen suits to require enforcement
- Requirements for a public hearing within ten months of receipt of a petition for designation of lands unsuitable for surface mining, and a decision within six months thereafter. (UN-092)

If additional legislation is required, it will have to be passed in a special session of the legislature if no federal pre-emption of lignite mining is desired. Otherwise, the state must take over a federal program that is already in place, which may give rise to administrative and even regulatory inconsistencies.

There are several controversial aspects of the Surface Mining Act related to the issuance of permits which may affect Texas lignite. In general, reclamation of surface mined land appears to be feasible throughout the state. However, land may be designated as unsuitable for surface mining if mining could "result in a substantial loss or reduction of long-range productivity of water supply, [including] aquifers and aquifer recharge areas." As is discussed in Section 4.3 above, the lignite in Texas is related to a complex aquifer system, and mining could alter the local hydrological conditions. Whether these effects are construed as falling under the criteria set forth in the Act has yet to be determined. Much of the ground water in the affected aquifer is either not suitable for use or is used only to water livestock. Furthermore, the aquifer is not continuous, much of the water being held in discontinuous large sand lenses. These factors will have to be taken into consideration in determining whether there is reason to designate any of the Texas lignite belt unsuitable.

Clarification of the concept of "aquifer" meant by the Act is also needed before permits can be issued. In East Texas, ground water is plentiful and often lies near the surface in small, unimportant perched bodies which would be impossible to restore. Defining these as "aquifers" in the sense of the Act could restrict permitting of substantial amounts of lignite.

Natural hazards may also serve as reason to designate an area unsuitable for mining. Included among these are areas subject to frequent flooding which could be construed to apply to parts of the broad Trinity and Brazos River floodplains underlain by lingite. These streams, however, are regulated by a number of dams which prevent heavy flooding.

Large quantities of lignite are also associated with the poorly documented Wilcox-Carrizo sands aquifer system. Even if not designated unsuitable, there is generally insufficent hydrological information available from a state or federal agency, as required in Section 507 (b)(11), to make a rigorous assessment of the hydrologic consequences of mining. In addition, the geohydrologic setting is so complex that it is not amenable to accurate analysis within the current state of the art. Finally, there is a possibility that in some areas it will not be possible to restore the original recharge characteristics after mining, as required in Section 515(b)(10).

5.1.6.3 Other Potential Issues Arising from PL 95-87

PL 95-87 contains several provisions with potentially wide-ranging consequences, although they are not among the more obviously controversial aspects of the law. The following discussion of these "sleepers" is conjectural and intended merely to point out possibilities.

Section 503 calls for coordination between the regulatory authority and any other agencies regulating any aspect of the proposed operation. This provision encourages coordinated planning in many areas where none now exists. A more comprehensive approach could come about, particularly in the area of water quality planning under Sections 208 and 303 of the Water Pollution Control Act Amendments. Also, the combined provisions of Titles V and VI of PL 95-87 can be read as effectively charging the state to develop a land use planning policy for all areas affected by surface mining for coal or non-coal minerals. This requirement would surely involve a coordinated planning effort with agencies responsible for other aspects of the environment.

A second potentially powerful provision of the Act, also represented in Texas law, is the provision that any person may petition to have an area designated unsuitable for mining. In addition to a maximum 16-month review process, the regulatory authority must prepare a detailed statement of its findings. Various interest groups could use this provision as an effective delaying tactic, in addition to the many legitimate petitioners who may come forward. Full exploitation of the technicalities of the EIS procedure have resulted in the cancellation and delay of controversial projects. If used in a similar manner, this right to petition, coupled with that of Section 520 providing for citizen suits to compel agency compliance with the Act, could conceivably operate against other State and Federal energy policies requiring rapid conversion to coal.

Finally, the regulations ultimately promulgated by the Department of the Interior could have an unspecified effect both on cost and timely availability of coal and lignite. Current information suggests that the draft regulations will be very detailed and will extend to the nation as a whole many requirements developed in states where it may often be difficult to prove that surface mining will be environmentally acceptable. Such a trend will hurt the competitive position of coal or lignite produced in states where there are few existing environmental problems.

5.1.6.4 Effects on the Competition Between Lignite and Imported Coal

Several aspects of PL 95-87 appear to be more likely to adversely affect the cost and reliability of supply of imported coal than of Texas lignite. Of particular importance is the provision in Section 510 that federal coal may not be leased without the permission of surface owners. It is generally believed, even among the drafters of the Act, that this provision makes it possible for surface owners to force coal companies to buy them out at a price reflecting the value of the mineral. This, in turn, is expected to drive up the cost of coal. In Texas, the only major federally-owned lignite supply is that underlying Camp Swift, and its surface is also in federal ownership.

The process of designating areas unsuitable for mining is far more likely to induce delays and uncertainties in the West and Appalachia than in Texas. Many areas are legitimately questionable with respect to permanent revegetation. In addition, strip mining national forest lands may be permitted only if the Secretary of the Interior finds that mining will not be incompatible with a range of loosely defined values (Section 522(e)(2)). Cultural and archaeological values may also conflict with mining in other areas, e.g., Four Corners. In Texas, there appear to be relatively few insurmountable environmental problems--aside from ambiguities regarding the interpretation of subsurface hydrological impacts--as well as very little public opposition to strip mining to date.

Specific provisions in Section 515 may be expected to increase the cost of producing coal in the steep Appalachian region, and in the prime farmlands of Illinois and the midwest. Again, Texas has no steep sloping coal lands, and lignite generally lies outside the prime farming areas.

It would require a much more thoroughgoing, quantitative analysis than the scope of this study permits to estimate the potential balance between the factors described above. Many will only become clear with experience. However, it seems probable that the more obvious inequities and impediments to timely development of coal and lignite will be resolved early, in view of the national commitment to increasing our reliance on domestic coal. Thus, it appears that in the short term -- roughly two to four years -- lignite could be favored over imported coal in Texas. Any improvement in its market position is likely to come about because of temporary uncertainties in the cost and reliability of imported coals. However, there is a vast amount of coal compared to the quantities which may be temporarily tied up while the provisions of PL 95-87 are worked out. It will probably not take long for production to move out into areas free of major impediment. Ultimately, therefore, it will probably be the regulations themselves which determine the long-term effect of the Act upon the amount of lignite mined in Texas.

5.1.7 Capital Availability

Since energy development is extremely costly, an important question concerns potential sources of capital. Two major questions must be answered: (1) will the money be available? (2) where will it come from?

The answer to the first question is "yes." According to several financial analysts (CA-440 and GR-350), the initial capital to finance construction of major facilities will be available through banks. Hence, no government aid is likely to be needed. However, the banks that have the amount of capital required are not located in Texas. Thus, the answer to the second question is "from outside Texas."

Texas law has not favored the growth of very large banks. Only recently with the growth of bank holding companies have some Texas banks become large enough to finance extremely large projects. Therefore, most front-end money for large projects will probably have to come from money-center banks such as

Continental Illinois, City Bank of New York, Chase Manhattan, and Bank of America.

In the long run, the backing for these large projects will come from bonds which will be purchased by major long term investors such as institutional investors, mutual funds, insurance companies, labor unions, universities, and the institutional sources.

The overall outlook with respect to capital availability in 1977 is very good. In the early 1970's the outlook was not as favorable mainly because utility companies were not being allowed to pass increased costs on to consumers. The current feeling is that utilities are being dealt with fairly by state utility commissions and are, therefore, good investments. An important caveat is that the continued bright prospects for utility companies are dependent upon the attitudes of utility regulatory commissions.

5.2 Issues Surrounding Impact Mitigation

5.2.1 Water Quality

Even though amendments to the Federal Water Pollution Control Act are presently being considered in Congress, mining and utility industry representatives in Texas claim that there will be no major problems in complying with existing 1977 and 1983 point-source discharge requirements.

As discussed above in Chapter 4, however, large-scale lignite development can potentially result in local effects on ground water quality. Secondary community growth can also generate additional pollutants both from point sources (primarily municipal sewage treatment effluents) and from area runoff. Strip-mined areas will generally be large--on the order of 20,000 acres or more--and can also potentially add contaminants through runoff. Institutional means of regulating these effects are less clear-cut than those governing point source discharges and some regulatory gaps exist.

Presently, authority over ground water quality in Texas is fragmented, with no comprehensive program of protection. Impacts of *in situ* processes (primarily solution mining of uranium, but also including lignite gasification) are being transferred from the Water Quality Board to the Railroad Commission. The Department of Health Resources, through its regulation of municipal solid waste disposal, also has a responsibility to protect ground water from contamination. The Water Development Board regulates oil well drilling and casing and protects ground water from contamination through these activities. A more comprehensive program could develop under the mandate of the Federal Safe Drinking Water Act. Funding to implement the Act has been received by the Department of Health Resources but no allotments have yet been made. A comprehensive program of ground water quality protection would entail overcoming some of the same public attitudes that hamper coordinated management of ground and surface water supply. Especially where land use or pumpage are regarded as contributing factors subject to regulation, opposition on the basis of property rights is likely to arise. For this reason, any major legislative initiative designed to integrate all aspects of ground water quality protection and to fill the existing regulatory gaps is unlikely in the near future.

The planning requirements of the Federal Water Pollution Control Act Amendments of 1972 include mandates for basinwide plans for waste discharges, including effluent limitations and total maximum daily pollutant loads (Section 303). Areawide waste treatment management plans are also called for, including non-point, mine-related and construction sources (Section 208). These planning processes potentially provide a framework for forward-looking, coordinated planning for the control of point- and non-point sources of pollutants. EPA emphasis on decreasing wastewater treatment plant discharge loads, however, has tended to eclipse these longer-range objectives.

Most of Texas is a non-designated area with respect to 208 planning and falls under the jurisdiction of the state's river authorities, which are also responsible for 303 basin planning. Non-point sources have for the most part been ignored in this highly dispersed planning framework. Emphasis has been placed on developing a system for case-by-case wasteload allocations, based on the existing inventory of discharges. Forecasting is not part of this process; instead, the allocation is updated yearly. Expected changes in water quantity, as they may affect the assimilative capacity of receiving streams, have not been included in the planning process. Thus, there is presently no attempt to plan systematically for simultaneous changes in waste loading and assimilative capacity, nor is there sufficient funding available for a comprehensive approach to this problem, based on forecasting. Such a program might allow more effective distribution of industrial and other growth, so as to use existing assimilative capacity more efficiently. Under the present case-by-case approach, much of this opportunity is likely to be foregone.

5.2.2 Growth Management

5.2.2.1 Planning for Increased Service Demand

For those communities expecting to grow rapidly because of lignite, planning can make the difference between successfully meeting increased service demands or falling short of the needs. For such services as sewer, water, streets, police and fire protection, the total lead time between recognizing the need and having the service available is typically three to four years (UN-092). Thus, after the need is recognized, it must first be quantified. Then a strategy for obtaining funds and implementing the needed measures must be devised.

There is a great variety of federal and state assistance available to fast-growing communities, especially those affected by energy development. Local governments, however, must initiate the planning process. The state provides technical assistance through a variety of agencies to communities facing growth problems. This assistance often takes the form of helping local governments to organize themselves to be better able to utilize federal program. Loans or grants are available from many federal sources, often overlapping each other in terms of the need addressed. Devising an optimal planning strategy involves examining this various array of resources and choosing a combination best suited to the individual community's needs. Then the necessary steps in applying for and receiving aid from the federal and state governments must be defined and coordinated.

The process of planning for lignite-related growth can become exceedingly complex, and require a degree of familiarity with state and federal bureaucracies not always found in municipal governments. Simple unawareness of the resources available will hamper the process for some small communities. Added to this are a number of other impediments often met with in small communities in Texas and other states.

First, the amount of planning lead time a community has to work with is to a large degree determined by information supplied by industry. There is a growing tendency, especially in the power industry, to inform community leaders early of planned activities. Solid advance information, three to four years before the need for additional municipal services, can serve a valuable time in a planning process often filled with unavoidable administrative delays.

Even when a community knows of its needs in advance, however, citizens and leaders may strongly oppose seeking help from other levels of government. Small communities often wish to avoid what they view as entanglement in immense big-government bureaucracies. More importantly, they may feel that the agencies assisting them will attempt to take away local powers of decision. Thus the larger federal agencies with money to spend may be viewed more as a threat than a resource.

The regional Councils of Government (COG's) appear presently to offer the most acceptable form of assistance to local governments. Being made up of these same, small bodies, they are often viewed as an extension of local government, rather than as an outside force. The COG's are sensitive to their members' interests, and in parts of Texas' lignite belt have already furnished substantial help. In general, however, their effectiveness is hampered by lack of funds and small staffs. They also lack implementation powers and can provide only information and advice. A study of ways to strengthen their role, as a way of opening channels to big-government aid programs, could yield useful results.

5.2.2.2 Financing

A recent study by the University of Texas (UN-092) suggests that the additional operating expenses of expanding communities could be met without special measures. Intergovernmental transfers of funds would often be needed, because taxes might not be equitably distributed among those entities actually serving the increased population. Some increase in local taxes, such as a city sales tax, may also be needed.

Capital expenses, however, involve special problems that may need novel solutions. The fundamental problem local governments face is the fact that the need for services develops faster than the tax base. This lag period may last five to eight years (UN-092). This is especially true for projects with large construction forces and long building schedules. Front-end money must be obtained to build needed facilities.

Bonding is one way of raising capital for needed expansion. However, local communities may have difficulty in issuing bonds. In particular, their tax base may not be large enough to secure substantial bond issues. Some states, such as Wyoming, include a state bonding authority which interposes itself between the local government and the capital market. With a larger tax base behind it, this bonding authority is often able to obtain bonding more readily and at lower cost than the local governments could have done. Texas has no such general authority, but a similar function is performed by the Texas Water Development Fund and Water Quality Funds. Both issue state bonds to provide funds to local governments for water distribution and treatment works.

Front-end financing may also be assisted by industry. Some large industrial developers may provide certain facilities, such as mobile housing parks, at their own expense. However, these instances are not usual, and are generally limited to activities which are in themselves sound investments. Industry money to finance such services as sewer and water may be obtained through a system of tax prepayment, followed by tax credit later on. This kind of system provides funds when needed, but has the disadvantage of reducing later revenues. At present, Texas has no such system. Industries can also help communities by guaranteeing bond issues. The Securities Exchange Commission, however, requires such guarantees to be carried as corporate liabilities. Some companies might not be able to carry such as additional financial burden.

The tax picture developing as a result of lignite development could become quite complex in some areas. This is particularly true if the projects are built close to county boundaries. Tax monies may not go to the counties furnishing the bulk of the services required. In these cases, counties receiving added revenues may not be willing to make adjustments in favor of neighboring counties. Sometimes, special purpose districts are called for. By special districting, the tax base supporting a particular service, such as hospital care, can be "defined" on the basis of potential use of the service.

In Texas, special problems arise when the entity developing a large power project is a municipal power authority or river basin authority. These bodies cannot be taxed, yet their new projects add to the burden of local governments. Citizens object strongly, not only to the added load on local services, but to the fact that other communities experience large tax benefits from other power projects. Possible solutions to the problem include a "gross proceeds" tax, proposed in the last session of the Texas Legislature. The Texas Municipal Power

Agency is presently looking into ways to provide services in lieu of taxes. Such services might include solid waste management, recreation, road improvements, fire protection, and health care (UN-092).

5.2.2.3 Land Use Planning

Key growth factors affecting land use will be the availability of housing and highway transportation. Sprawl problems are most likely in areas where these facilities are inadequate and must be expanded. A second factor contributing to sprawl or disconnected urban growth is the availability of funds to build new municipal sewer and water systems. Many communities now have sewage treatment systems which do not now meet EPA standards, or which will not carry added loads due to growth. Public funding for all of these communities is simply not available, and many of the smaller ones may experience difficulty in issuing bonds. Where these services cannot be provided by local governments, developers may build self-contained housing tracts using package treatment systems. These may be located well away from existing towns, adding to highway traffic pressure, school transportation demand, and other local service demands. Communities may be unable to influence their location, timing or size. More importantly, unless developers understand the need for lead time, local governments may not be informed of planned developments in time to provide needed services. The land-use impacts of lignite development can almost certainly be lessened or controlled by some form of collective goal-setting. This could be accomplished either by local governments or voluntarily by developers. In Texas, however, opposition to land-use planning is strong and of long standing. Property owners view planning as a threat to their freedom to profit from using their land as they choose. A few larger communities, such as Austin, have instituted a municipal plan, and smaller towns near large cities and becoming interested in planning. There is little actual enforcement power in these plans as yet, however.

Texas has not yet experienced large-scale lignite development. Its residents are now largely in favor of growth, because of its obvious and and substantial economic benefits. The lignite lies generally in a region in which these benefits are particularly needed. However, experience in other states, such as Wyoming, suggests that after development gets under way, public opinion may shift. In these cases, the early comments of citizens often reflect a very incomplete picture of the future. Expectations are high, and there is no basis of experience with probable growth-related impacts. This gap becomes suddenly and clearly apparent when the impacts begin to be felt.

Thus, information appears to be a key factor that can moderate these "surprises". Information regarding what to expect must be communicated to the people who stand to be affected. Equally important, developers, industries, and service-providing agencies need to know the values of the people themselves. The aesthetic impacts of a power plant, for example, may be more important to local residents, than its emissions. A mechanism to promote smooth, two-way transfer of this kind of information is needed. Operating effectively, it could save a great deal of future dissatisfaction. At the most, it could avoid divisive local "backlash" that would slow needed energy development and hamper planning.

5.3 Camp Swift: A Case Study of Federally Owned Texas Lignite

The bulk of the Texas lignite resource will be developed by private industry on privately owned land. A significant exception is lignite at Camp Swift, a large abandoned World War II military training reservation located some 30 miles east of Austin. Strippable lignite reserves on this federally owned property are estimated in excess of 100 million tons or enough to supply a 750 MWe unit for at least 20 years. Most of the available resource lies within some 4,000 acres of the 11,740 acre tract.[1]

By virtue of a provision in the Federal Coal Leasing Act Amendments of 1976 (P.L. 94-377), coal and lignite on U.S. military property can be leased to publicly owned utilities. This measure was specifically designed to benefit several publicly owned Central Texas utilities hard hit by some of the highest priced and least dependable fuel supplies in the nation. Under the provision of P.L. 94-377, the Secretary of the Interior can execute coal leases with the consent of the Department of Defense.

The Lower Colorado River Authority (LCRA) has applied for a leasing permit under the Act. The municipally owned utilities of Austin and San Antonio may join with LCRA in the development of the Camp Swift lignite.

Despite recent changes in Federal coal leasing policy, officials with the Department of Interior state that they are "actively processing" the LCRA application and that they foresee no delays in the original schedule which called for leasing in

---

[1] Personal communication with LCRA staff.

1979. Although an environmental impact statement will be required prior to any development of the Camp Swift reserves, some preliminary area environmental assessments have been conducted. These are reflected in the following general comments regarding impacts resulting from the development of Camp Swift lignite.

For the publicly owned utilities likely to be involved, Camp Swift offers several positive features. The size of the property and the extent of the resource is large enough to mine as a single unit thus avoiding the need to acquire many additional parcels of land. Competition for the leases is limited by law to publicly owned utilities and, by the economics of lignite transportation, to nearby facilities. A third advantage deals with a situation discussed in Section 5.1.6, the legal conflicts over assignment of surface mined lignite. Since all of the property has single surface and mineral right owner, Camp Swift lignite development will not be impeded by this problem.

Finally, it should be noted that LCRA and the city-owned utilities of Austin and San Antonio enjoy a variety of options for using the Camp Swift lignite. The LCRA and the City of Austin are jointly constructing a coal-fired power plant 40 miles southeast of Camp Swift. The two 550 MWe units of Fayette Power Plant are scheduled for completion in 1979 and 1980. To maximize the flexibility of fuel supplies, both units will be built to burn either western coal or Texas lignite. The Camp Swift reserve, with existing rail connections to the Fayette Power Plant, is the logical source for Texas lignite.

A second option is the conversion of the gas-fired boilers on the 600 MWe LCRA Gideon Power Plant located a few miles south of Camp Swift on Lake Bastrop. LCRA is performing engineering studies to determine the feasibility of boiler conversion to lignite. Other options include the construction of a new plant near the Camp Swift reserves or, less likely, the shipment of lignite to facilities near Austin or San Antonio.

The new Surface Mining Control and Reclamation Act of 1977 (P.L. 95-87) introduces some new requirements for obtaining rights to Camp Swift lignite and a permit to mine it, but they do not place the area at a disadvantage relative to other in-state or out-of-state sources. In particular, the Secretary of Interior is required to inventory all Federal lands to determine what areas may be unsuitable for mining. Permitting under the Act may continue, however, during this review.

There appear to be no natural impediments to successful reclamation at Camp Swift. The overburden above the lignite is generally low in sand, and this may require selective replacement of overburden to create the best possible texture for plant growth. Overlying soils, based on their classification by the Soil Conservation Service, are expected to be only moderately suitable, or poorly suited to use in reclamation. Thus stockpiling and replacing topsoil might not be cost effective in comparison to selective overburden placement (PA-190). Under Section 515 (b)(5) of the surface mining act, the requirement for replacing topsoil may be waived if subsurface strata can be shown to provide a more effective plant growth medium.

The new law does preclude new coal mining operations which "will adversely affect any publicly owned park" (Section 522(b)). Camp Swift is roughly seven miles from the closer of two states parks. It does not appear at this point, however, that mining at Camp Swift would interfere with their use or aesthetic enjoyment.

In general, the socio-economic impacts of developing a mine at Camp Swift would be similar to those arising from a similar operation anywhere in the central portion of the lignite belt. An exception, however, arises in the matter of taxation. At present, Camp Swift, as a federal property, is a non-taxable entity -- as is LCRA and other publicly owned utilities. This poses the problem that local governments may be subject to increased demands for services without an increased tax base to meet these demands. However, the same act which permits the leasing of Camp Swift lignite also provides that the Federal government must share half of its coal royalty revenues with the affected states for use by local governments in coping with social and economic impacts resulting from federal coal development. (The minimum Federal royalty share is 12.5 percent of the value of the resource.) Therefore, it appears that there is a mechanism to mitigate impacts through assistance to local governments in the Camp Swift vicinity.

No ecological impacts of significance outside of the mined area are likely to result. The landscape is already patchy from prior clearing and disturbance, and the additional disturbance of mining will probably not occasion any changes that have not already occurred. Some loblolly pines occur on the Camp Swift property, but the bulk of the so-called "Lost Pines" occur on the sandier soils of the Carrizo outcrops, rather than on the soils of the Calvert Bluff Formation, where mining will take place.

Studies conducted during the summer of 1977 by the Texas Bureau of Economic Geology and not yet released indicate that the mining of Camp Swift lignite can be accomplished without adversely affecting surface or subsurface water resources. However, applicants seeking permits under the new surface mining act must demonstrate that no material damage will occur to hydrologic systems outside the immediate mining areas after reclamation (Section 510(b)(3). Since much of the Camp Swift lignite lies below the water table, as is the case in much of the lignite belt, final regulatons issued pursuant to this provision conceivably may limit development of deeper seams.

Recognizing the uncertainty regarding hydrological impacts, the outlook for lignite development at Camp Swift appears generally positive. If a reclamation plan can be designed to mitigate any possible hydrological impacts, mining at Camp Swift appears to pose no major environmental problems.

5.4 Summary Evaluation

Perhaps the most significant conclusion of this study is that the problems Texas must solve to develop its lignite are largely institutional rather than environmental. This makes Texas -- and by extension, the overall Gulf Coast region -- unique in comparison to the Nation's other energy-producing regions. Of course, there will be potentially adverse impacts on the environment, but it presently appears that most of them can be successfully mitigated. No insurmountable drawbacks arising from the nature of the environment itself have been found. However, there will probably be problems in implementing available solutions. These are mainly "people problems," arising from the region's particular goals and governmental style, which conflict with those of the Federal government. Thus environmental planning and management in the Gulf Coast Resource Region will be largely a political undertaking rather than a technological one.

Compared with the Western states, Appalachia, and the Midwest, the environment of the Gulf Coast appears very well suited for surface mining and industrial development. First, its climate, topography, geology, and soils generally favor reclamation; there appear to be no areas in Texas where success is truly questionable. Also, there is presently no reason to expect a problem with acid mine drainage. Some impacts on ground water systems are likely but Gulf Coast lignites are not themselves aquifers. Therefore, these impacts are likely to be on a small scale, and much less difficult to mitigate than in large parts of the West. Conflicts over water use are forecast, but the economic tradeoffs involved are far less basic than those faced by the Western states. The boom-town syndrome already developing in parts of the west is much subdued in Texas and the Gulf Coast. In this region, the resource is not isolated from large population and trade centers. Also, the extensive areas of natural vegetation and prime wildlife habitat threatened by surface mining and land use changes are not found in the Texas lignite belt. Similarly, prime farmlands lie generally outside the lignite belt, as contrasted with the Midwest. Finally, the Gulf Coast lignite region has none of the topographic and climatic conditions which cause concern over air pollution in other regions. Thus, the Gulf Coast, of all the coal-producing regions of the Nation, offers the fewest natural impediments to developing its resource.

The institutional and political problems faced by the Gulf Coast also have a regional flavor distinct from areas with different attitudes and histories.

The most pervasive influence involved in these problems arises from the region's attitudes about resource use. Texas and the Gulf Coast have evolved a governmental style that reflects conditions of resource abundance and exploitation. But those conditions have changed pervasively and suddenly. Like the rest of the Nation, the Gulf Coast must make the transition into a future constrained by higher energy costs and increased need to protect the environment. A successful transition, however, must recognize the need to deal with the existing cultural and institutional structure. Evolution is indicated, rather than surgery.

Federal energy and environmental policies place much more emphasis on centralized management of common resources than currently exists in Texas, due to popular attitudes. The criteria used in these policies are National, and often conflict with the actual situation in the region and state. In addition to incurring environmental and financial burdens as a result of this conflict, the region has had much of its problem-solving flexibility pre-empted by federal authority. First by setting uniform goals throughout the Nation, and second by specifying required means to meet them, the federal approach reduces the region's ability to tailor its own solutions. This tends to produce more uniform progress toward national goals, but the progress may be sub-optimal. From the standpoint of these national goals, however, some form of standard approach may be necessary to keep them from being lost among the interests of the different regions.

An aspect of the federal approach, which seems not to have been directly intended, is _de facto_ land-use and economic planning. Taken together, the provisions of the federal clean air law, surface mining control, and clean water law have a strongly restrictive effect on land use and industrial siting. Other laws also contribute to the effect. States, in complying with the environmental planning provisions of all of these federal statutes, are effectively required to make broad-based plans for future industrial siting and land use. Most important, the planning criteria provided by these laws are primarily oriented toward environmental control, and largely do not recognize region-specific economic factors. It is these factors, however, which are the driving force behind growth and land-use changes. To a degree, then, regions are faced with a national planning requirement which arises incidentally from environmental policy. With such indirect origin, it is not surprising that this planning "policy" conflicts strongly with any potential regional efforts to plan comprehensively.

To sum up, then, the major "environmental" problems facing the Gulf Coast resource region will likely be institutional. These are founded in strong national-regional conflicts, and in state-level policies which have developed under conditions of resource abundance. To make the transition into the future, policies at all levels affecting this region need to find a common basis. Ideally, this basis will allow for regional perspectives needed to find the best solutions to the region's special problems. It will also recognize the fact that rising energy costs and increasing environmental stress now require an increased degree of cooperative problem-solving and planning.

The complexities of the existing net of Federal and state policies are great and extend beyond lignite to encompass all energy resources. Nowhere is the national-regional conflict over energy and environmental values more fundamentally developed than in the Gulf Coast resource region. Consequently, a major policy analysis study of this area, along the lines of EPA's Integrated Technology Assessment program, would amply repay the effort. Unlike other resource regions, such a study would not run the risk of merely reiterating environmental problems based on unchangeable natural conditions. A study of the Gulf Coast will provide information about situations that can be changed, and provide the framework for effective federal-state cooperation that can reap real benefits in the short term. In addition, means of resolving national-regional conflicts which develop from this analysis may be applied in other regions as well. Because the potential utility of such a study is so great, and because this significant energy resource region is not yet represented in the ITA program, it should be seriously considered.

6.0 RESEARCH NEEDS

This study was undertaken solely to outline the major environmental aspects of lignite development in Texas, based on knowledge already available within Radian Corporation. It has accordingly identified those areas where problems and issues arise, but at a very generalized level. To turn these observations into a useful framework for state and federal planning will require further in-depth research. The following recommendations for further study fall into four categories:

- Forecasting
- Baseline data and impact prediction
- Developing national/regional problem-solving strategies
- Developing state-level problem-solving strategies

These recommendations do not exhaust all areas where more knowledge would be useful. Rather, they are intended to point out major directions and focal points for planning additional work. Emphasis has been placed on the kind of study necessary to resolve policy and regulatory issues. A single package could be made of all of these recommendations in the form of a regional technology assessment. As discussed in Chapter Five, this approach has many advantages and is highly recommended. However, it is felt that additional work in any one of these areas would be useful by itself.

6.1 Forecasting

The lignite use forecast used in this study is very rudimentary. It consists of a very broad envelope, rather than a set of more realistic scenarios. When Congress passes national energy policy legislation, it should be possible to construct a series of scenarios reflecting the basic directions of this

Preceding page blank

very important piece of legislation. These should compare possible implementation strategies not yet decided upon. They should also display the consequences of exercising the state's role in implementing these policies.

A significant flaw in the present forecast is its failure to include industrial demand. This component could be added through the use of economic forecasts made by the Texas Water Development Board, as well as OBERS projections. The newly updated Texas Input-Output Economic Model, available at Radian, can be used to trace the economic effects of different energy policy options as they determine lignite demand.

A finer geographic perspective is also needed. Splitting the forecast into river basin increments would increase its value for planning. The development scenarios could also be keyed to the distribution and quality of lignite within the basins.

Finally, if the study is to be extended across the Gulf Coast resource region as a whole, a better definition of the entire resource is needed. This may prove difficult, since little drilling has been done in Louisiana, Arkansas, Alabama, and Mississippi. The last two states have bituminous coal as well as lignite, which makes their potential development pattern more complex.

6.2 Baseline Data and Impact Analysis

Every topic discussed in Chapters Three and Four will benefit from a more thorough investigation. Expanding to a regional scope will require extensive data-gathering. Socioeconomic data needs are particularly pressing. A much more exhaustive inventory of existing conditions and resources must be made before the extent and scale of growth management needs can be assessed.

Also, further effort is needed to identify ecologically sensitive areas. Since most of the land affected by Gulf Coast lignite development is privately owned, a backlog of exploration and inventory similar to that in the western states does not exist. Use of remote sensing imagery, consultation with local researchers and wildlife managers, and some field reconnaissance are recommended methods.

Even in Texas, where geological exploration has been extensive, not enough is known about ground water to identify possible problems connected with mining. The Surface Mining Control and Reclamation Act of 1977 requires determination of probable hydrologic consequences as a condition for obtaining a mining permit (Section 507(b)(11)). This information is the responsibility of an "appropriate Federal or State agency." Thus, the need for further ground water hydrological study is immediate.

A first step in pinning down this area would be an in-depth survey of existing information. Then problem zones could be identified where more data must be gathered. Existing mine operations could also be studied with respect to their effect on ground water movement. Ground water quality impacts, such as contamination from leached metals, long-term chloride and sulfate buildup, and progressive acidification of buried pyrite-containing overburden, should also be studied. Both laboratory tests and field observations could be employed.

The potential for in-stream flow depletion also needs further definition. Models are being developed to help predict the effects of water use on estuarine inflow, and relate them to biotic needs. These should be used as a means of comparing and evaluating the effects of various state and federal-level policy options for managing water use and supply. In particular, the potential to mitigate flow depletion impacts by controlled reservoir releases should be investigated.

While there appear to be no major drawbacks to land reclamation, much more specific information is needed. To date, both the geographic extent of mining and range of reclamation techniques has been limited to some of the most favorable areas of Central and East Texas. More information is needed about overburden, climate, and potential land use options in South and East Texas. In particular, options exist for greatly improving wildlife habitat through reclamation, at least in some areas. If this opportunity is to be exploited, appropriate techniques must be developed. Comparative costs of reclaiming land for various purposes should be developed and keyed to intra-regional differences. The availability of plant materials, especially native species, should also be investigated.

6.3 Developing National-Regional Problem Solving Strategies

A basic method of comparing and evaluating the effects of federal policies at the regional level is economic analysis. State and regional input-output models, or other analytical tools, can be used to generate quantitative predictions useful in planning for a variety of impacts. Topics which could--and should--be evaluated in this way include:

- Alternative lignite demand forecasts (reflecting national energy policy)
- Competition between users for scarce water supplies (under various national water policy options)
- Secondary impacts of federal clean air policy, related to regional lignite and coal development

Economic modeling could also be used to evaluate policies at the state level, not directly concerned with determining the regional implications of federal decisions. Among these more local issues are water allocation to reduce inequities in distribution. Secondary impacts in other economic sectors could also arise because of changes in labor availability and wage competition. These would also bear investigation with an economic model.

In Chapter Five, the point was made that a number of Federal environmental laws, taken together, constitute a very broad mandate for land use planning and economic growth management. An in-depth analysis of this problem would doubtless bring to light a number of difficulties that might otherwise not be foreseen. Early recognition of what this planning mandate may mean at the regional level can provide the basis for federal-state cooperation to develop a workable strategy. The following topics should be investigated:

- What specific requirements are contained in the applicable Federal laws?
- What does the composite picture look like? What relationships or conflicts exist between the separate planning mandates?
- What additional factors, specific to the region, need to be included to avoid inequities and provide a realistic basis for actual problem-solving?
- What will the planning process cost the states? The Federal Government?

A major commitment to improving efficiency of energy use has been made by the present administration. The effect of the transition from oil and gas to coal and lignite on energy efficiency is therefore a topic of immediate interest. It is also one where substantial national-regional conflict could be avoided by a thorough analysis of the implications of federal policy. The relationships of different federal policies to each other should also be considered. It is the net effect of all of these policies which will ultimately define the context for regional efforts at energy management. The forthcoming national energy legislation, clean air policy, and national water policy options will probably be the major factors to study. In addition to projecting regional options as early as possible, it will be useful to study opportunities for energy conservation. Existing drawbacks and impediments to conservation, co-generation, and other forms of cooperative energy use through the transition period should be identified. Promising approaches should be recommended for support.

6.4 Developing State-Level Problem-Solving Strategies

Among the most pressing lignite-related problems which must be solved at the state level is that of water supply. Several options have been described in Chapter 5. Comparative analysis of their effectiveness, economic and environmental costs would be a useful tool in planning--and obtaining support--for future action. The Texas Department of Water Resources has made extensive investigations of such options as joint ground- and surface-water management. Other topics worth investigation are:

- Land use conflicts with respect to reservoir construction

- Legal and regulatory options for state governments to promote water conservation and protect instream flows

- Possible state responses to national water policy-making

States must also deal with the impacts of lignite development on land use, as it affects non-point source water pollution. For example, the scanty availability of funds for building new sewage treatment systems in many growth communities appears likely to promote scattered residential and commercial development. An investigation of the extent of such impacts, which fall under the planning provisions of the Federal Water Pollution Control Act Amendments, would provide a basis for planning control strategies. An estimate of the appropriate timeframe available for such planning, as well as its cost, would also be useful.

Growth management is itself a critical need. Not only will it be necessary to define the extent of the problem, there is a great need to identify all the many sources of state and federal assistance available to affected communities. Potential problems could be broken out by areas--such as sewage treatment, schools, water supply and roads. These could then be discussed in terms of the entities responsible and the resources available to them to deal with them. An estimate of the time required and the probability of success for obtaining assistance from various quarters would be a valuable aid. A "manual" based on this investigation would be of use both to communities and to industries seeking to help communities cope with growth. Since massive "boom town" expansion is not envisioned, this effort could allow significant numbers of communities to avoid the adverse effects which can accompany unplanned, moderate growth.

A major deficiency of this study is the absence of air quality modeling studies. Modeling can be used first to calculate ambient conditions in rural areas. This will help determine the availability of PSD increments. Using this baseline, it would be of interest to calculate the effect on allowable plant spacing of various PSD classification options. In particular, the impact of re-zoning appropriate areas Class I and of re-zoning portions of the lignite region Class III needs to be assessed. Modeling should be used to calculate, rather than estimate, the distances at which plume interactions could occur. Also related to clean air policy would be an investigation of the potential for regulation of "new" pollutants, especially trace metals, to alter the relative economics of lignite versus imported coal.

Finally, the impact of the problem of assigning strippable lignite to the surface or the mineral estate warrants further study. First, the extent of such severed ownership should be determined. This information is not presently available except in individual county records. Then, the proportion of such leases should be determined which expire or come up for renewal within the timeframe in which a mine built before 1985 could be expected to operate. This information should provide a basis for evaluating the potential for a rise in lignite cost through lease renegotiation.

BIBLIOGRAPHY

BA-560 Baughman, Martin L., et al , Provision of Electric Power in Texas: Key Issues and Uncertainties, Technical Report, 2 Vols., Executive Summary, Number 77-100, Austin, Texas, University of Texas, Center of Energy Studies, March 1977.

BE-431 Beale, Calvin, The Revival of Population Growth in Non-Metropolitan America, USDA-ERS #605, U.S. Department of Agriculture, 1975.

BI-035 Birks, L.S. and J.V. Gilfrich, Development of X-Ray Fluorescence Spectroscopy for Elemental Analysis of Particulate Matter in the Atmosphere and in Source Emissions. Phase 2 Evaluation of Commercial Multiple Crystal Spectrometer Instruments, NRL Report 8717, Research Triangle Park, N.C., National Environmental Research Center, Division of Chemistry and Physics, 1973.

BL-118 Blair, Frank, "The Biotic Provinces of Texas", Reprint, Texas Journal Science 2(1), (1950).

CA-440 Carson, Glen, Private Communication, Petroleum Engineering Office, First City National Bank, Houston, Texas, August 12, 1977.

CO-373 Cobe Laboratories, Inc., A Survey of the Subsurface Saline Water of Texas, Vol. 1, TxWDB Report, 157, Austin, Texas, TxWDB, October, 1972.

DO-108 Doyle, William S., Strip Mining of Coal, Environmental Solutions, Park Ridge, New Jersey, Noyes Data, 1976.

Preceding page blank

DO-143 Down, C.G. and J. Stocks, *Environmental Impact of Mining*, New York, Halsted Press, 1977.

ED-073 Edgar, T.F. and W.R. Kaiser, "Resource Development/ Utilization. The Potential of *In Situ* Lignite Gasification in Texas", in *Geology of Alternate Resources in the South-Central United States*, Michael D. Campbell, et al., eds., Houston Geological Society, 1977.

EN-102 Environmental Protection Agency, *The Control of Pollution Caused by Hydrographic Modifications*, EPA 430/ 9-73-107, Washington, D.C., 1973.

FI-159 Fisher, William L., "The National Energy Plan: Projected Impacts on Future Texas Oil and Gas Production and Value", in *Preliminary Assessment of the President's National Energy Plan*, May 11, 1977, Austin, Texas, University of Texas at Austin, 1977.

GA-R-242 Gavande, Sam, *Developing Reclamation Plan for Proposed Surface Mined Lands of Texas*, Austin, Texas, Radian Corporation, April 1977.

GO-190 Gould, F.W., *Texas Plants, A Checklist and Ecological Summary*, MP-585/Revised, College Station, Texas, Texas A&M University System, Texas Agricultural Experiment Station, January 1975.

GR-350 Greenwood, R.B., Private Communication, City National Bank, Austin, Texas, August 12, 1977.

GR-355 Grubb, Herbert W., Structure of the Texas Economy, Vol. 2, Draft Final Report, Austin, Texas, Department of Water Resources, 1977.

HE-201/3c Henry, Christopher, D., Land Resources Inventory of Lignite Strip-Mining Areas, East Texas, Geological Circular 76-2, Austin, Texas, University of Texas, Bureau of Economic Geology, 1976.

HO-389 Hoffman, Herman William, Jr., "Water for Lignite Development in Texas", Presented at the Gulf Coast Lignite Conference, Austin, Texas, June 1976.

HO-400 Holloway, M., Texas Energy Outlook: The Next Quarter Century, Austin, Texas, Governor's Advisory Council, 1977.

JO-257 Jordan, T.G. "The Texas Appalachia", Annals Assoc. Amer., Geograph. 60 (1970).

JO-258 Jordan, T.G. "Population Origins in Texas, 1850", Geograph. Rev. 59, 83-103 (1969).

JO-259 Jordan, T.G., Map Supplement Number 13, Annals Assoc. Am. Geograh. 60(13), (1970).

KA-152 Kaiser, W.R., Texas Lignite: Near Surface and Deep-Basin Resources, Bureau of Economic Geology R.I. 79, Austin, Texas, Bureau of Economic Geology, University of Texas at Austin, 1974.

MC-325 McKie, James W., "The Effects of the Proposals for Natural Gas Pricing in the National Energy Plan on the Energy Economy of Texas", in Preliminary Assessment of the President's National Energy Plan, May 11, 1977, Austin, Texas, University of Texas, 1977

ME-189 Meinig, D.W., Imperial Texas, Austin, Texas, University of Texas Press, 1969.

NA-172 National Academy of Engineering, Rehabilitation Potential of Western Coal Lands, Ford Energy Policy Project, Cambridge, Masschusetts, Ballinger, 1974.

NA-360 National Climatic Center, Local Climatological Data, Asheville, North Carolina, (1976-1977).

OR-021 Orton, Robert, Climatography of Texas, Austin, Texas, National Weather Service.

PA-190 Pattarozzi, Michael, B.A., Economic and Environmental Aspects of Lignite Strip Mining, Bastrop County, Texas, Thesis, Presented to the Faculty of the Graduate School of The University of Texas at Austin, August 1975.

RE-118 Real Estate Research Corporation, The Cost of Sprawl. Environmental and Economic Costs of Alternative Residential Development Patterns at the Urban Fringe, 1974.

SE-184 Self, D.M. and D.R. Williamson, "Trend Areas and Exploration Techniques", in Geology of Alternate Resources in the South-Central United States, Michale D. Campbell, et al., eds, Houston Geological Society, 1977.

SO-004 Southern Research Institute, A Manual of Electrostatic Precipitator Technology. Part I. Fundamentals, NAPCA Control CPA 22-69-73, Birmingham, Alabama, 1970.

SO-005 Southern Research Institute, A Manual of Electrostatic Precipitator Technology, Part 2, Application Areas, Contract No. CPA 22-69-73, Birmingham, Alabama, 1970.

TE-231 Texas Water Development Board, The Texas Water Plan, Austin, Texas, 1968.

TE-301 Texas Water Development Board, Continuing Water Resources Planning and Development for Texas, Draft Report, 2 Vols., Austin, Texas, May 1977.

TE-RF-257 Texas Almanac, 1976-1977, Dallas Morning News.

TO-028 Todd, David Keith, ed., The Water Encyclopedia, Port Washington, New York, Water Information Center, 1970.

TW-008 Tweeten, Luther, and George L. Brinkman, Micropolitan Development, Theory and Practice of Greater Rural Economic Development, Ames, IA, Iowa State University Press, 1976.

UN-085 University of Texas, Lyndon B. Johnson School of Public Affairs, Energy in Texas, Vol. 2, Policy Alternatives, Policy Research Project Report, Austin, Texas, 1974.

UN-092 University of Texas at Austin, Lyndon Baines Johnson School of Public Affairs, Public Policies Affecting Lignite Development in Texas, Draft Report, Austin, Texas, 1977.

US-155 U.S. Geological Survey, The National Atlas of the United States of America, Washington, D.C., 1970.

US-308 U.S. Department of Commerce, Environmental Data Service, Climatic Atlas of the United States, June 1968.

US-343 U.S. Department of Commerce, Social and Economic Statistics Administration, County and City Data Book, 1972, Washington, D.C., GPO, 1973.

US-394 U.S. Geological Survey, *Water Resources Data for Texas 1966 2 Parts: Part 1, Surface Water Records; Part 2, Water Quality Records*, Washington, D.C., 1967.

US-395 U.S. Geolgoical Survey, *Water Resources Data for Texas, 1967, 2 Parts. Part 1, Surface Water Records; Part 2, Water Quality Records*, Washington, D.C., 1968.

US-396 U.S. Geological Survey, *Water Resources Data for Texas, 1968, 2 Parts: Part 1, Surface Water Records; Part 2, Water Quality Records*, Washington, D.C., 1969.

US-397 U.S. Geological Survey, *Surface Water Supply of the U.S., 1961-65. Part 8, Western Gulf of Mexico Basin. Volume 1, Basins from Mermentau River to Colorado River*, Survey Water-Supply Paper 1922, Washington, GPO, 1969.

US-398 U.S. Geological Survey, *Surface Water Supply of the U.S., 1961-65. Part 8, Western Gulf of Mexico Basin, Volume 2, Basins from Lavaca River to Rio Grande*, Survey Water-Supply Paper 1923, Washington, GPO, 1970.

US-632 U.S. Bureau of the Census, *Estimates of the Population of Counties, July 1, 1973 and 1974*, Current Population Reports Series P-25, No. 620, February 1976.

US-676 U.S. Geological Survey, Water Resources Division, *Water Resources Data for Texas, 1975*, 3 Vols., USGS/WRD/HD-76/025, Austin, Texas, June 1976.

WA-185 Warner, Don L., *Rationale and Methodology for Monitoring Ground Water Polluted by Mining Activities*, EPA 600/4-74-003, Contract No. 68-01-0759, Task 3, Santa Barbara, California, General Electric Company, TEMPCO Center for Advanced Studies, July 1974.

WE-225 Wen, C.Y. and L.S. Fan, *Absorption of Sulfur Dioxide in Spray Column and Turbulent Contacting Absorbers*, Final Report, EPA-600/2-75-023, Morgantown, West Virginia, West Virginia University, August 1975.

WH-124 White, David M. and Olin B. Clemons, *Coal and Lignite: Mining, Transportation and Utilization Needs for Texas*, Technical Report 77-003, Austin, Texas, Governor's Energy Advisory Council, 1977.

WH-125 White, D.M., "Coal and Lignite Power Generation", *Texas Energy Report*, No. 22, 6-8 (1976).

WI-297 Wielchowsky, C.C., et al., "Frontier Areas and Exploration Techniques", in *Geology of Alternate Resources in the South-Central United States*, Michael D. Campbell, et al., eds., Houston Geological Society, 1977.